I

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

REPORT

OF

PROGRESS OF STREAM MEASUREMENTS

FOR

THE CALENDAR YEAR 1905

PREPARED UNDER THE DIRECTION OF F. H. NEWELL

PART XII.—The Great Basin Drainage

BY

M. C. HINDERLIDER, G. L. SWENDSEN, and HENRY THURTELL

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CONTENTS.

In all sections of the country permanent gaging stations are maintained for general statistical purposes, to show the conditions existing through long periods. They are also used as primary stations, and their records, in connection with short series of measurements, serve as bases for estimating the flow at other points in the drainage basin.

During the calendar year 1905 the division of hydrography has continued measuring the flow of streams on the same general lines as in previous years. Many new and improved methods have been introduced, by which the accuracy and value of the results have been increased. Approximately 800 regular gaging stations were maintained during the year, and an exceptionally large number of miscellaneous measurements and special investigations were made. The "Report of Progress of Stream Measurements," which contains the results of this work, is published in a series of fourteen Water-Supply and Irrigation Papers, Nos. 165 to 178, as follows:

No. 165. Atlantic coast of New England drainage.
No. 166. Hudson, Passaic, Raritan, and Delaware river drainages.
No. 167. Susquehanna, Gunpowder, Patapsco, Potomac, James, Roanoke, and Yadkin river drainages.
No. 168. Santee, Savannah, Ogeechee, and Altamaha rivers and eastern Gulf of Mexico drainages.
No. 169. Ohio and lower eastern Mississippi river drainages.
No. 170. Great Lakes and St. Lawrence River drainages.
No. 171. Hudson Bay, and upper eastern and western Mississippi River drainages.
No. 172. Missouri River drainage.
No. 173. Meramec, Arkansas, Red, and lower western Mississippi river drainages.
No. 174. Western Gulf of Mexico and Rio Grande drainages.
No. 175. Colorado River drainage.
No. 176. The Great Basin drainage.
No. 177. The Great Basin and Pacific Ocean drainages in California.
No. 178. Columbia River and Puget Sound drainages.

These papers embody the data collected at the regular gaging stations, the results of the computations based on the observations, and such other information as may have a direct bearing on the study of the subject, and include, as far as practicable, descriptions of the basins and the streams draining them.

For the purpose of introducing uniformity into the reports for the various years the drainages of the United States have been divided into eleven grand divisions, which have been again divided into secondary divisions, as shown in the following list. The Progress Report has been made to conform to this arrangement, each part containing the data for one or more of the secondary divisions. The secondary divisions have in most cases been redivided, and the facts have been arranged, as far as practicable, geographically.

Drainage basins in the United States.

NORTHERN ATLANTIC DRAINAGE BASINS.

St. John.
St. Croix.
Penobscot.
Kennebec.
Androscoggin.
Presumpscot.
Saco.
Merrimac.
Connecticut.
Blackstone.
Thames.
Housatonic.
Hudson.
Passaic.
Raritan.
Delaware.
Susquehanna.
Potomac.
Minor Chesapeake Bay.
Minor northern Atlantic.

SOUTHERN ATLANTIC DRAINAGE BASINS.

James.
Chowan.
Roanoke.
Tar.
Neuse.
Cape Fear.
Great Pedee (Yadkin).
Santee.
Savannah.
Ogeechee.
Altamaha.
Minor Southern Atlantic.

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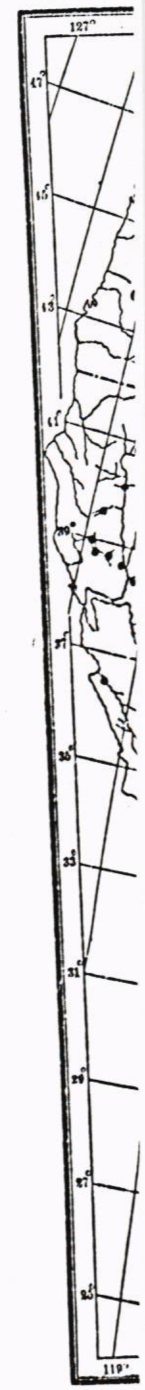

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Roanoke, and Yadkin river

astern Gulf of Mexico drain-

River drainages.

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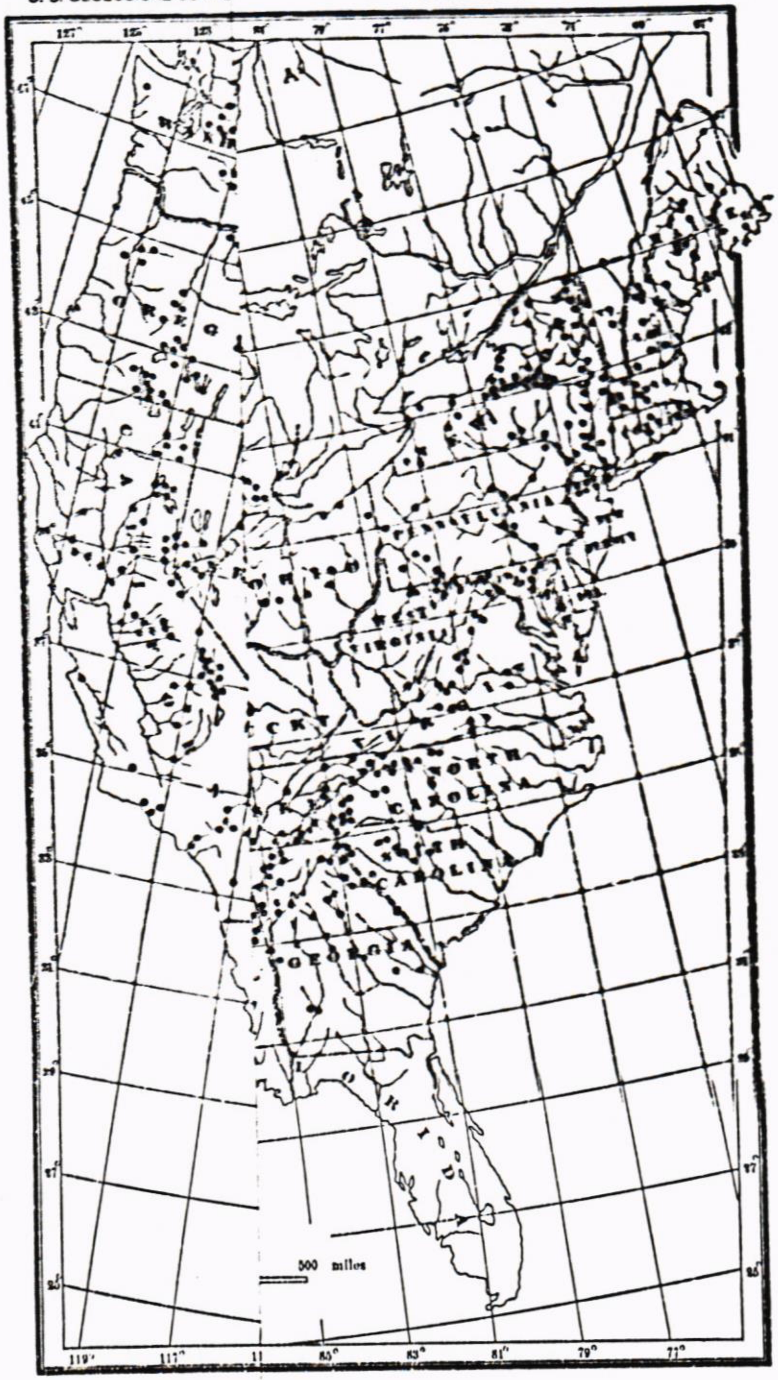
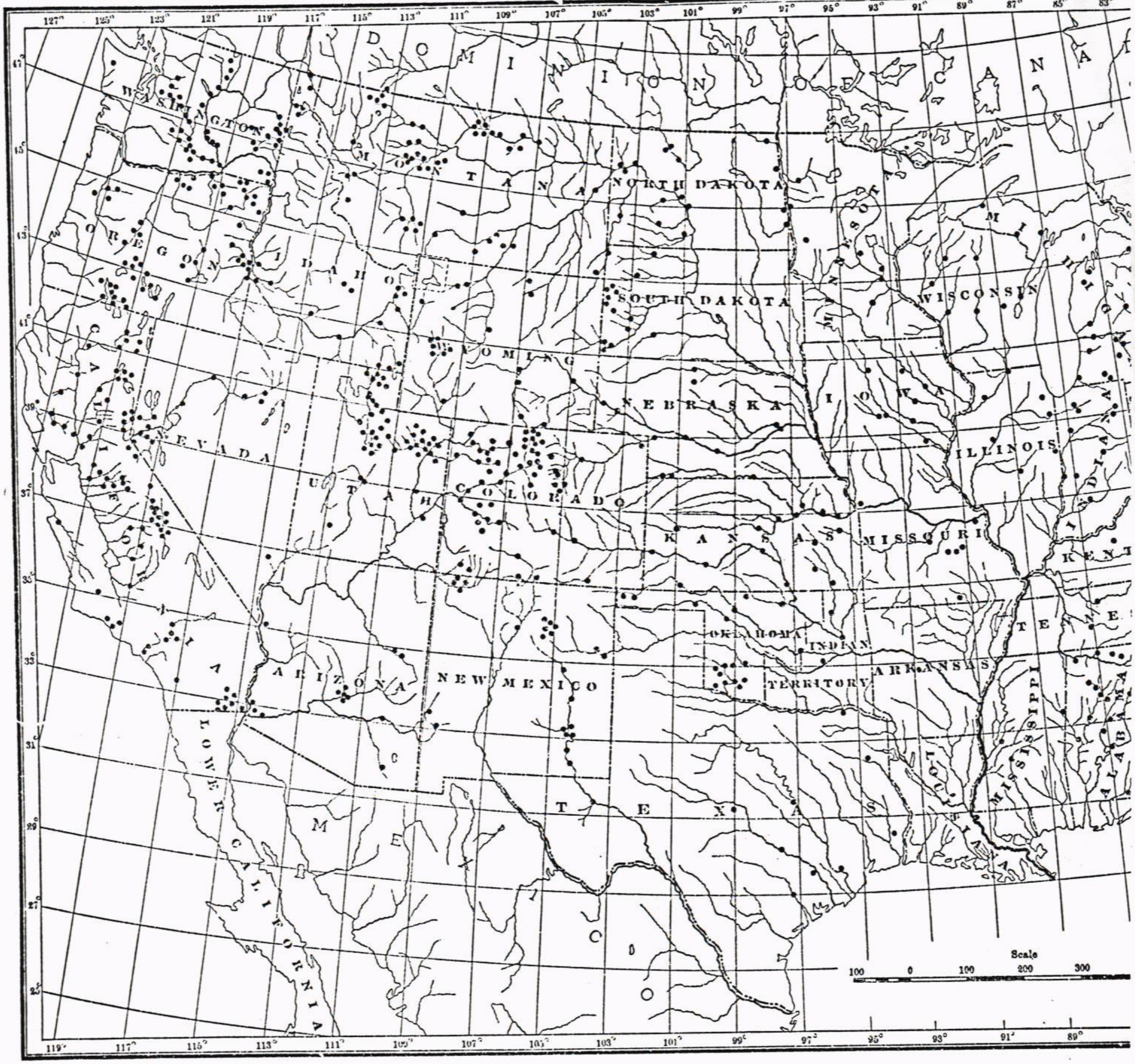
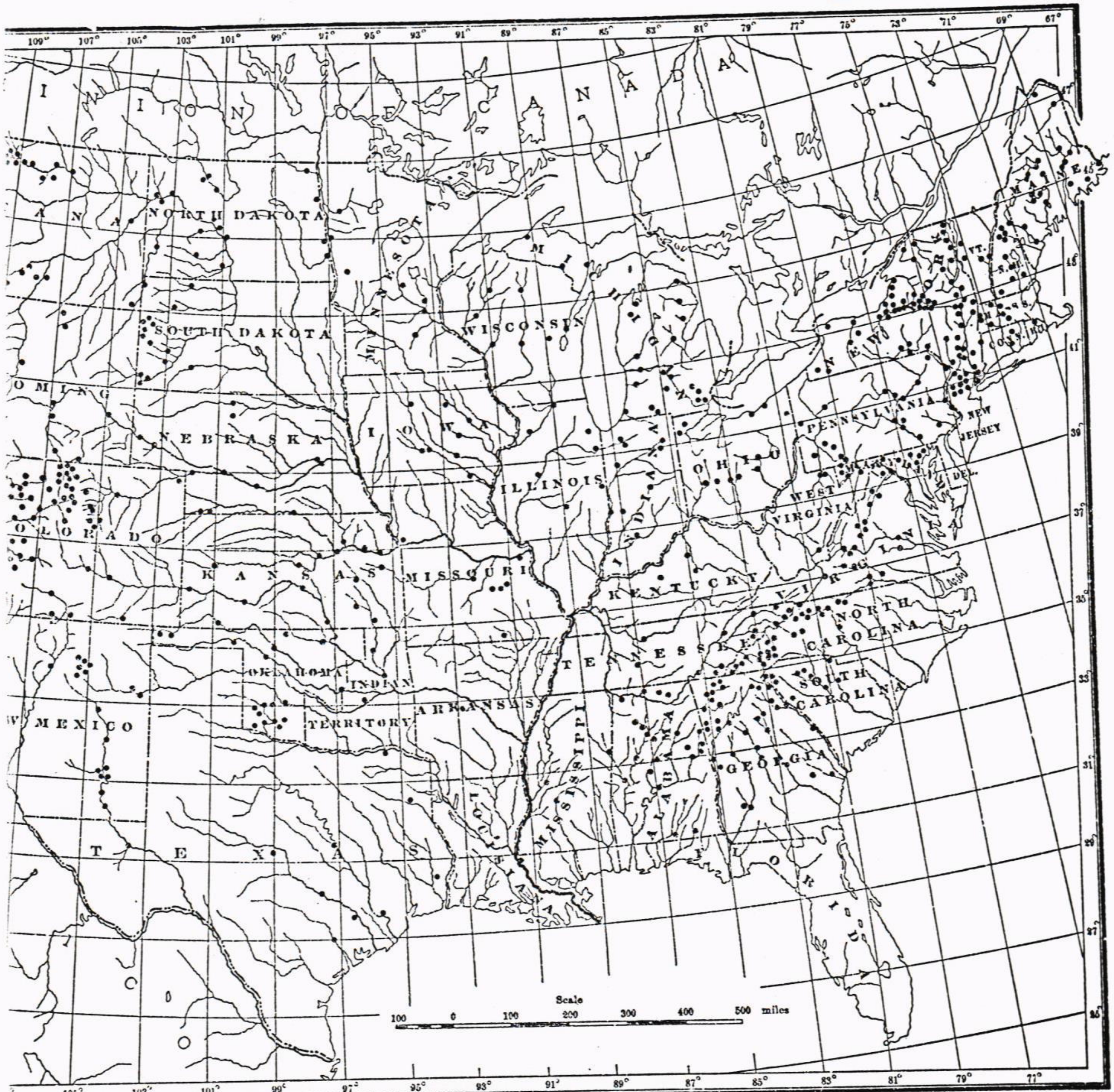


DURING 1905.

U. S. GEOLOGICAL SURVEY



MAP OF THE UNITED STATES, SHOWING LOCATION OF PRINCIPAL RIVER STATIONS MAINTAI



D STATES, SHOWING LOCATION OF PRINCIPAL RIVER STATIONS MAINTAINED DURING 1905.

EASTERN GULF OF MEXICO DRAINAGE BASINS.

Suwanee.
Apalachicola.
Mobile.
Pearl.
Minor eastern Gulf of Mexico.

EASTERN MISSISSIPPI RIVER DRAINAGE BASINS.

Lower eastern Mississippi.
Ohio.
Upper eastern Mississippi.

ST. LAWRENCE RIVER DRAINAGE BASINS.

Lake Superior.
Lake Michigan.
Lake Huron.
Lake St. Clair.
Lake Erie.
Niagara River.
Lake Ontario.
Lake Champlain (Richelieu River).
Minor St. Lawrence.

WESTERN MISSISSIPPI RIVER DRAINAGE BASINS.

Upper western Mississippi.
Missouri.
Meramec.
Lower western Mississippi.
Arkansas.
Red.

WESTERN GULF OF MEXICO DRAINAGE BASINS.

Sabine.
Neches.
Trinity.
Brazos.
Colorado (of Texas).
Guadelupe.
San Antonio.
Nueces.
Rio Grande.
Minor western Gulf of Mexico.

COLORADO RIVER DRAINAGE BASIN.

THE GREAT BASIN.

Wasatch Mountains.
Humboldt.
Sierra Nevada.
Minor streams in Great Basin.

PACIFIC COAST DRAINAGE BASINS.

Southern Pacific.
San Francisco Bay.
Northern Pacific.
Columbia.
Puget Sound.

HUDSON BAY DRAINAGE BASINS.

DEFINITIONS.

The volume of water flowing in a stream—the "run-off" or "discharge"—is expressed in various terms, each of which has become associated with a certain class of work. These terms may be divided into two groups—(1) those which represent the rate of flow, as second-feet, gallons per minute, miner's inch, and run-off in second-feet per square mile; and (2) those which represent the actual quantity of water, as run-off in depth in inches and acre-feet. They may be defined as follows:

"Second-foot" is an abbreviation for cubic foot per second, and is the rate of discharge of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot per second. It is generally used as a fundamental unit from which others are computed.

"Gallons per minute" is generally used in connection with pumping and city water supply.

The "miner's inch" is the rate of discharge of water passing through an orifice 1 inch square under a head which varies locally. It has been commonly used by miners and irrigators throughout the West, and is defined by statute in each State in which it is used. In most States the California miner's inch is used, which is the fiftieth part of a second-foot.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly both as regards time and area.

"Run-off in inches" is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is usually expressed in depth in inches.

"Acre-foot" is equivalent to 43,560 cubic feet, and is the quantity required to cover an acre to the depth of 1 foot. It is commonly used in connection with storage for irrigation work. There is a convenient relation between the second-foot and the acre-foot. One second-foot flowing for twenty-four hours will deliver 86,400 cubic feet, or approximately 2 acre-feet.

EXPLANATION OF TABLES.

For each regular gaging station are given, as far as available, the following data:

1. Description of station.
2. List of discharge measurements.
3. Gage-height table.
4. Rating table.
5. Table of estimated monthly and yearly discharges and run-off, based on all the facts obtained to date.

The descriptions of stations give such general information about the locality and equipment as would enable the reader to find and use the station. They also give, as far as possible, a complete history of all the changes since the establishment of the station that would be factors in using the data collected.

The discharge-measurement table gives the results of the discharge measurements made during the year, including the date, the name of the hydrographer, the gage height, the area of cross section, the mean velocity, and the discharge in second-feet.

The table of daily gage heights gives the daily fluctuations of the surface of the river as found from the mean of the gage readings taken each day. The gage height given in the table represents the elevation of the surface of the water above the zero of the gage. At most stations the gage is read in the morning and in the evening.

The rating table gives discharges in second-feet corresponding to each stage of the river as given by the gage heights.

In the table of estimated monthly discharge the column headed "Maximum" gives the mean flow for the day when the mean gage height was highest; this is the flow as given in the rating table for that mean gage height. As the gage height is the mean for the day, there might have been short periods when the water was higher and the corresponding discharge larger than that given in this column. Likewise, in the column of "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" is the average flow for each second during the month. On this are based computations for the three remaining columns, which are defined above.

In the computations for the tables of this report the following general and special rules have been used:

Fundamental rules for computation.

1. The highest degree of precision consistent with the rational use of time and money is imperative.

2. All items of computation should be expressed by at least two, and not more than four, significant figures.

3. Any measurement in a vertical velocity, mean velocity, or discharge curve whose per cent of error is five times the average per cent of error of all the other measurements should be rejected.

4. In reducing the number of significant figures, or the number of decimal places, by dropping the last figure, the following rules apply:

(*a*) When the figure in the place to be rejected is less than 5, drop it without changing the preceding figure. Example: 1,827.4 becomes 1,827.

(*b*) When the figure in the place to be rejected is greater than 5, drop it and increase the preceding figure by 1. Example. 1,827.6 becomes 1,828.

(*c*) When the figure in the place to be rejected is 5 and it is preceded by an even figure, drop the 5. Example: 1,828.5 becomes 1,828.

(*d*) When the figure in the place to be rejected is 5 and it is preceded by an odd figure, drop the 5 and increase the preceding figure by 1. Example: 1,827.5 becomes 1,828.

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No decimals are to be used when
2. Daily discharges shall be ap
3. Monthly means are to be carr
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4. Second-feet per square mile
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100 United States gallons per
100 United States gallons per
1,000,000 United States gallon
1,000,000 United States gallon
1,000,000 cubic feet equal 22.95
1 acre-foot equals 325,850 gall
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1 inch equals 2.54 centimeter
1 foot equals 0.3048 meter.
1 yard equals 0.9144 meter.
1 mile equals 1.60935 kilomet
1 mile equals 1,760 yards; eq
1 square yard equals 0.836 sq
1 acre equals 0.4047 hectare.
1 acre equals 43,560 square fe
1 acre equals 209 feet square,
1 square mile equals 259 hect
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1 cubic foot equals 7.48 gallo
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1 cubic yard equals 0.7646 cu
1 cubic mile equals 147,198,0
1 cubic mile equals 4,667 sec
1 gallon equals 3.7854 liters.
1 gallon equals 8.36 pounds
1 gallon equals 231 cubic inc
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1 troy pound equals 5,760 gr
1 meter equals 39.37 inches.
1 meter equals 3.280833 feet.
1 meter equals 1.093611 yar
1 kilometer equals 3,281 feet

CONVENIENT EQUIVALENT.

Special rules for computation.

1. Rating tables are to be constructed as closely as the data on which they are based will warrant. No decimals are to be used when the discharge is over 50 second-feet.

2. Daily discharges shall be applied directly to the gage heights as they are tabulated.

3. Monthly means are to be carried out to one decimal place when the quantities are below 100 second-feet. Between 100 and 10,000 second-feet the last figure in the monthly mean shall be a significant figure. This also applies to the yearly mean.

4. Second-feet per square mile and depth in inches for the individual months shall be carried out to at least three significant figures, except in the case of decimals where the first significant figure is preceded by one or more naughts (0), when the quantity shall be carried out to two significant figures. Example: 1.25, 0.125, 0.012, 0.0012. The yearly means for these quantities are always to be expressed in three significant figures and at least two decimal places.

CONVENIENT EQUIVALENTS.

1 second-foot equals 50 California miner's inches.
1 second-foot equals 38.4 Colorado miner's inches.
1 second-foot equals 40 Arizona miner's inches.
1 second-foot equals 7.48 United States gallons per second; equals 448.8 gallons per minute; equals 646,272 gallons for one day.
1 second-foot equals 6.23 British imperial gallons per second.
1 second-foot for one year covers 1 square mile 1.131 feet deep; 13.572 inches deep.
1 second-foot for one year equals 0.00074 cubic mile; equals 31,536,000 cubic feet.
1 second-foot equals about 1 acre-inch per hour.
1 second-foot falling 10 feet equals 1.136 horsepower.
100 California miner's inches equal 15 United States gallons per second.
100 California miner's inches equal 77 Colorado miner's inches.
100 California miner's inches for one day equals 4 acre-feet.
100 Colorado miner's inches equal 2.60 second-feet.
100 Colorado miner's inches equal 19.5 United States gallons per second.
100 Colorado miner's inches equal 130 California miner's inches.
100 Colorado miner's inches for one day equal 5.2 acre-feet.
100 United States gallons per minute equal .223 second-foot.
100 United States gallons per minute for one day equal 0.44 acre-foot.
1,000,000 United States gallons per day equal 1.55 second-feet.
1,000,000 United States gallons equal 3.07 acre-feet.
1,000,000 cubic feet equal 22.95 acre-feet.
1 acre-foot equals 325,850 gallons.
1 inch deep on 1 square mile equals 2,323,200 cubic feet.
1 inch deep on 1 square mile equals 0.0737 second-foot per year.
1 inch equals 2.54 centimeters.
1 foot equals 0.3048 meter.
1 yard equals 0.9144 meter.
1 mile equals 1.60935 kilometers.
1 mile equals 1,760 yards; equals 5,280 feet; equals 63,360 inches.
1 square yard equals 0.836 square meter.
1 acre equals 0.4047 hectare.
1 acre equals 43,560 square feet; equals 4,840 square yards.
1 acre equals 209 feet square, nearly.
1 square mile equals 259 hectares.
1 square mile equals 2.59 square kilometers.
1 cubic foot equals 0.0283 cubic meter.
1 cubic foot equals 7.48 gallons; equals 0.804 bushel.
1 cubic foot of water weighs 62.5 pounds.
1 cubic yard equals 0.7646 cubic meter.
1 cubic mile equals 147,198,000,000 cubic feet.
1 cubic mile equals 4,667 second-feet for one year.
1 gallon equals 3.7854 liters.
1 gallon equals 8.36 pounds of water.
1 gallon equals 231 cubic inches (liquid measure).
1 pound equals 0.4536 kilogram.
1 avoirdupois pound equals 7,000 grains.
1 troy pound equals 5,760 grains.
1 meter equals 39.37 inches. Log. 1.595165.
1 meter equals 3.28083 feet. Log. 0.515984.
1 meter equals 1.093611 yards. Log. 0.038863.
1 kilometer equals 3,281 feet; equals five-eighths mile, nearly.

1 square meter equals 10.764 square feet; equals 1.196 square yards.
1 hectare equals 2.471 acres.
1 cubic meter equals 35.314 cubic feet; equals 1.308 cubic yards.
1 liter equals 1.0567 quarts.
1 gram equals 15.43 grains.
1 kilogram equals 2.2046 pounds.
1 tonneau equals 2,204.6 pounds.
1 foot per second equals 1.097 kilometers per hour.
1 foot per second equals 0.68 mile per hour.
1 cubic meter per minute equals 0.5886 second-foot.
1 atmosphere equals 15 pounds per square inch; equals 1 ton per square foot; equals 1 kilogram per square centimeter.
Acceleration of gravity equals 32.16 feet per second every second.
1 horsepower equals 550 foot-pounds per second.
1 horsepower equals 76 kilogram-meters per second.
1 horsepower equals 746 watts.
1 horsepower equals 1 second-foot falling 8.8 feet.
1⅓ horsepowers equal about 1 kilowatt.

To calculate water power quickly: $\frac{\text{Sec.-ft.} \times \text{fall in feet}}{11}$ = Net horsepower on water wheel, realizing 80 per cent of the theoretical power.

Quick formula for computing discharge over weirs: Cubic feet per minute equals $0.4025\, l\sqrt{h^3}$; l=length of weir in inches; h=head in inches flowing over weir, measured from surface of still water.

To change miles to inches on map:

Scale 1:125000, 1 mile=0.50688 inch.
Scale 1:90000, 1 mile=0.70400 inch.
Scale 1:62500, 1 mile=1.01376 inches.
Scale 1:45000, 1 mile=1.40800 inches.

FIELD METHODS OF MEASURING STREAM FLOW.

The methods used in collecting these data and in preparing them for publication are given in detail in Water-Supply Papers No. 94 (Hydrographic Manual, U. S. Geol. Survey) and No. 95 (Accuracy of Stream Measurements). In order that those who use this report may readily become acquainted with the general methods employed, the following brief description is given.

Streams may be divided, with respect to their physical conditions, into three classes—(1) those with permanent beds; (2) those with beds which change only during extreme low or high water; (3) those with constantly shifting beds. In estimating the daily flow special methods are necessary for each class. The data on which these estimates are based and the methods of collecting them are, however, in general the same.

There are three distinct methods of determining the flow of open-channel streams—(1) by measurements of slope and cross section and the use of Chezy's and Kutter's formulas; (2) by means of a weir; (3) by measurements of the velocity of the current and of the area of the cross section. The method chosen for any case depends on the local physical conditions, the degree of accuracy desired, the funds available, and the length of time that the record is to be continued.

Slope method.—Much information has been collected relative to the coefficients to be used in the Chezy formula, $v=c\sqrt{rs}$. This has been utilized by Kutter, both in developing his formula for c and in determining the values of the coefficient n, which appears therein. The results obtained by the slope method are in general only roughly approximate, owing to the difficulty in obtaining accurate data and the uncertainty of the value for n to be used in Kutter's formula. The most common use of this method is in estimating the flood discharge of a stream when the only data available are the cross section, the slope, as shown by marks along the bank, and a knowledge of the general conditions.

Weir method.—When funds are available and the conditions are such that sharp-crested weirs can be erected, these offer the best facilities for determining flow. If dams are suitably situated and constructed, they may be utilized for obtaining reliable estimates of flow. The conditions necessary to insure good results may be divided into two classes—(1) those relating to the physical characteristics of the dam itself and (2) those relating to the diversion and use of water around and through the dam.

The physical requirements are as follows: (*a*) Sufficient height of dam, so that backwater will not interfere with free fall over it; (*b*) absence of leaks of appreciable magnitude; (*c*) topography or abutments which confine the flow over the dam at high stages; (*d*) level crests, which are kept free from obstructions caused by floating logs or ice; (*e*) crests of a type for which the coefficients to be used in $Q=c\,b\,h^{\frac{3}{2}}$, or some similar standard weir formula, are known (see Water-Supply Paper No. 150); (*f*) either no flash boards or exceptional care in reducing leakage through them and in recording their condition.

Preferably there should be no diversion of water through or around the dam. Generally, however, a dam is built for purposes of power or navigation, and part or all of the water flowing past it is diverted for such uses. This water is measured and added to that passing over the dam. To insure accuracy in such estimates the amount of water diverted should be reasonably constant. Furthermore, it should be so diverted that it can be measured, either by a weir, a current meter, or a simple system of water wheels which are of standard make, or which have been rated as meters under working conditions, and so installed that the gate openings, the heads under which they work, and their angular velocities may be accurately observed.

The combination of physical conditions and uses of the water should be such that the estimates of flow will not involve, for a critical stage of considerable duration, the use of a head, on a broad-crested dam, of less than 6 inches. Moreover, when all other conditions are good, the cooperation of the owners or operators of the plant is still essential if reliable results are to be obtained.

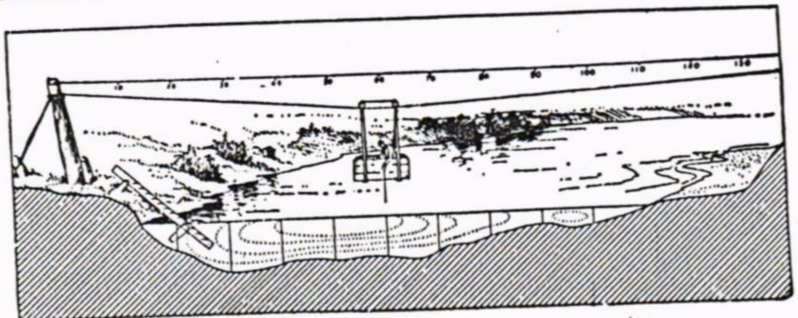

FIG. 1.—Cable station showing section of river, car, gage, etc.

A gaging station at a weir or dam has the general advantage of continuity of record through the period of ice and floods, and the disadvantages of uncertainty of coefficient to be used in the weir formula and of complications in the diversion and use of the water.

Velocity method.—The determination of the quantity of water flowing past a certain section of a stream at a given time is termed a discharge measurement. This quantity is the product of two factors—the mean velocity and the area of the cross section. The mean velocity is a function of surface slope, wetted perimeter, roughness of bed, and the channel conditions at, above, and below the gaging section. The area depends on the contour of the bed and the fluctuations of the surface. The two principal ways of measuring the velocity of a stream are by floats and current meters.

Great care is taken in the selection and equipment of gaging stations for determining discharge by velocity measurements in order that the data may have the required degree of accuracy. Their essential requirements are practically the same whether the velocity is determined by meters or floats. They are located as far as possible where the channel is straight both above and below the gaging section; where there are no cross currents, backwater, or boils; where the bed of the stream is reasonably free from large projections of a permanent character; and where the banks are high and subject to overflow only at flood stages. The station must be so far removed from the effects of tributary streams and dams or other artificial obstructions that the gage height shall be an index of the discharge.

Certain permanent or semipermanent structures, usually referred to as "equipment," are generally pertinent to a gaging station. These are a gage for determining the fluctuations of the water surface, bench marks to which the datum of the gage is referred, permanent marks on a bridge or a tagged line indicating the points of measurement, and, where the current is swift, some appliance (generally a secondary cable) to hold the meter in position in the water. As a rule, the stations are located at bridges if the channel conditions are satisfactory, as from them the observations can more readily be made and the cost of the equipment is small.

The floats in common use are the surface, subsurface, and tube or rod floats. A corked bottle with a flag in the top and weighted at the bottom makes one of the most satisfactory surface floats, as it is affected but little by wind. In case of flood measurements, good results can be obtained by observing the velocity of floating cakes of ice or débris. In case of all surface-float measurements coefficients must be used to reduce the observed velocity to the mean velocity. The subsurface and tube or rod floats are intended to give directly the mean velocity in the vertical. Tubes give excellent results when the channel conditions are good, as in canals.

In measuring velocity by a float, observation is made of the time taken by the float to pass over the "run," a selected stretch of river from 50 to 200 feet long. In each discharge measurement a large number of velocity determinations are made at different points across the stream and from these observations the mean velocity for the whole section is determined. This may be done by plotting the mean positions of the floats as indicated by the distances from the bank as ordinates and the corresponding times as abscissas. A curve through these points shows the mean time of run at any point across the stream, and the mean time for the whole stream is obtained by dividing the area bounded by this curve and its axis by the width. The length of the run divided by the mean time gives the mean velocity.

The area used in float measurements is the mean of the areas at the two ends of the run and at several intermediate sections.

The essential parts of the current meters in use are a wheel of some type, so constructed that the impact of flowing water causes it to revolve, and a device for recording or indicating the number of revolutions. The relation between the velocity of the moving water and the revolutions of the wheel is determined for each meter. This rating is done by drawing the meter through still water for a given distance at different speeds, and noting the number of revolutions for each run. From these data a rating table is prepared, which gives the velocity per second for any number of revolutions.

Many kinds of current meters have been constructed. They may, however, be classed in two general types—those in which the wheel is made up of a series of cups, as the Price, and those having a screw-propeller wheel, as the Haskell. Each meter has been developed for use under some special condition. In the case of the small Price meter, which has been largely developed and extensively used by the United States Geological Survey, an attempt has been made to get an instrument which could be used under practically all conditions.

Current-meter measurements may be made from a bridge, cable, boat, or by wading; and gaging stations may be classified in accordance with such use. Fig. 1 shows a typical cable station.

In making the measurement an arbitrary number of points are laid off on a line perpendicular to the thread of the stream. The points at which the velocity and depth are observed are known as measuring points and are usually fixed at regular intervals, varying from 2 to 20 feet, depending on the size and condition of the stream. Perpendiculars dropped from the measuring points divide the gaging section into strips. For each strip or pair of strips the mean velocity, area, and discharge are determined independently, so that conditions existing in one part of the stream may not be extended to parts where they do not apply.

Three classes of methods of measuring velocity with current meters are in general use—multiple-point, single-point, and integration.

The three principal multiple-point methods in general use are the vertical velocity curve, 0.2 and 0.8 depth; and top, bottom, and mid-depth.

In the vertical velocity curve method a series of velocity determinations are made in each vertical at regular intervals, usually from 0.5 to 1 foot apart. By plotting these velocities as abscissas and their depths as ordinates, and drawing a smooth curve among the resulting points, the vertical velocity curve is developed. This curve shows graphically the magnitude and changes in velocity from the surface to the bottom of the stream. The mean velocity in the vertical is then obtained by dividing the area bounded by this velocity curve and its axis by the depth. On account of the length of time required to make a complete measurement by this method, its use is limited to the determination of coefficients for purposes of comparison and to measurements under ice.

In the second multiple-point method the meter is held successively at 0.2 and 0.8 of the depth and the mean of the velocities at these two points is taken as the mean velocity for that vertical. On the assumption that the vertical velocity curve is a common parabola with horizontal axis, the mean of the velocities at 0.22 and 0.79 of the depth will give (closely) the mean velocity in the vertical. Actual observations under a wide range of conditions show that this second multiple-point method gives the mean velocity very closely for open-water conditions where the depth is over 5 feet and the bed comparatively smooth, and moreover the indications are that it will hold nearly as well for ice-covered rivers.

In the third multiple-point method the meter is held at mid-depth, at 0.5 foot below the surface and at 0.5 foot above the bottom, and the mean velocity is determined by dividing by 6 the sum of the top velocity, four times the mid-depth velocity, and the bottom velocity. This method may be modified by observing at 0.2, 0.6, and 0.8 depth.

The single-point method consists in holding the meter either at the depth of the thread of mean velocity or at an arbitrary depth for which the coefficient for reducing to mean velocity has been determined.

Extensive experiments by vertical velocity curves show that the thread of mean velocity generally occurs at from 0.5 to 0.7 of the total depth. In general practice the thread of mean velocity is considered to be at 0.6 depth, at which point the meter is held in a majority of the measurements. A large number of vertical velocity-curve measurements taken on many streams and under varying conditions show that the average coefficient for reducing the velocity obtained at 0.6 depth to mean velocity is practically unity.

In the other principal single-point method the meter is held near the surface, usually 1 foot below, or low enough to be out of the effect of the wind or other disturbing influences. This is known as the subsurface method. The coefficient for reducing the velocity taken at the subsurface to the mean has been found to be from 0.85 to 0.95, depending on the stage, velocity, and channel conditions. The higher the stage the larger the coefficient. This method is specially adapted for flood measurements, or when the velocity is so great that the meter can not be kept at 0.6 depth.

The vertical-integration method consists in moving the meter at a slow, uniform speed from the surface to the bottom and back again to the surface, and noting the number of revolutions and the time taken in the operation. This method has the advantage that the velocity at each point of the vertical is measured twice. It is well adapted for measurements under ice and as a check on the point methods.

The area, which is the other factor in the velocity method of determining the discharge of a stream, depends on the stage of the river, which is observed on the gage, and on the general contour of the bed of the stream, which is determined by soundings. The soundings are usually taken at each measuring point at the time of the discharge measurement, either by using the meter and cable or by a special sounding line or rod. For streams with permanent beds standard cross sections are usually taken during low water. These sections serve to check the soundings which are taken at the time of the measurements, and from them any change which may have taken place in the bed of the stream can be detected. They are also of value in obtaining the area for use in computations of high-water measurements, as accurate soundings are hard to obtain at high stages.

In computing the discharge measurements from the observed velocities and depths at various points of measurement, the measuring section is divided into elementary strips, as shown in fig. 1. and the mean velocity, area, and discharge are determined separately for either a single or a double strip. The total discharge and the area are the sums of those for the various strips, and the mean velocity is obtained by dividing the total discharge by the total area.

The determination of the flow of an ice-covered stream is difficult, owing to diversity and instability of conditions during the winter period and also to lack of definite information in regard to the laws of flow of water under ice. The method now employed is to make frequent discharge measurements during the frozen periods by the vertical velocity-curve method and to keep an accurate record of the conditions, such as the gage height to the surface of the water as it rises in a hole cut in the ice, the thickness and character of the ice, etc. From these data an approximate estimate of the daily flow can be made by constructing a rating curve (really a series of curves) similar to that used for open channels, but considering, in addition to gage heights and discharge, varying thickness of ice. Such data as are available in regard to this subject are published in Water-Supply Paper No. 146, pages 141-148.

OFFICE METHODS OF COMPUTING RUN-OFF.

There are two principal methods of estimating run-off, depending on whether or not the bed of the stream is permanent.

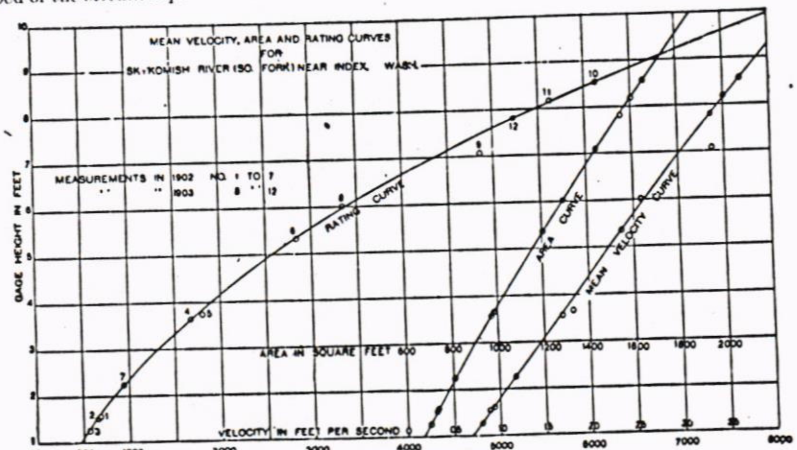

FIG. 2—Rating, area, and mean-velocity curves for South Fork of Skykomish River near Index, Wash.

For stations on streams with permanent beds the first step in computing the run-off is the construction of the rating table, which shows the discharge corresponding to any stage of the stream. This rating table is applied to the record of stage to determine the amount of water flowing. The construction of the rating table depends on the method used in measuring flow.

For a station at a weir or dam, the basis for the rating table is some standard weir formula. The coefficients to be used in its application depend on the type of dam and other conditions near its crest. After inserting in the weir formula the measured length of crest and assumed coefficient, the discharge is computed for various heads and the rating table constructed.

The data necessary for the construction of a rating table for a velocity-area station are the results of the discharge measurements, which include the record of stage of the river at the time of measurement, the area of the cross section, the mean velocity of the current, and the quantity of water flowing. A thorough knowledge of the conditions at and in the vicinity of the station is also necessary.

The construction of the rating table depends on the following laws of flow for open, permanent channels: (1) The discharge will remain constant so long as the conditions at or near the gaging station remains constant. (2) The discharge will be the same whenever the stream is at a given stage, if the change of slope due to the rise and fall of the stream be neglected. (3) The discharge is a function of and increases gradually with the stage.

The plotting of results of the various discharge measurements, using gage heights as ordinates, and discharge, mean velocity, and area as abscissas, will define curves which show the discharge, mean velocity, and area corresponding to any gage height. For the development of these curves there should be, therefore, a sufficient number of discharge measurements to cover the range of the stage of the stream. Fig. 2 shows a typical rating curve with its corresponding mean-velocity and area curves.

As the discharge is the product of two factors, the area and the mean velocity, any change in either factor will produce a corresponding change in the discharge. Their curves are therefore constructed in order to study each independently of the other.

The area curve can be definitely determined from accurate soundings extending to the limits of high water. It is always concave toward the horizontal axis or on a straight line, unless the banks of the stream are overhanging.

The form of the mean-velocity curve depends chiefly on the surface slope, the roughness of the bed, and the cross section of the stream. Of these, the slope is the principal factor. In accordance with the relative change of these factors the curve may be either a straight line, convex or concave toward either axis, or a combination of the three. From a careful study of the conditions at any gaging station the form which the vertical velocity curve will take can be predicted, and it may be extended with reasonable certainty to stages beyond the limits of actual measurements. Its principal use is in connection with the area curve in locating errors in discharge measurements and in constructing the rating table.

The discharge curve is defined primarily by the measurements of discharge, which are studied and weighted in accordance with the local conditions existing at the time of each measurement. The curve may, however, best be located between and beyond the measurements by means of curves of area and mean velocity. The discharge curve under normal conditions is concave toward the horizontal axis and is generally parabolic in form.

In the preparation of the rating table the discharge for each tenth or half-tenth on the gage is taken from the curve. The differences between successive discharges are then taken and adjusted according to the law that they shall either be constant or increasing.

The determination of the daily discharge of streams with changeable beds is a difficult problem. In case there is a weir or dam available, a condition which seldom exists on streams of this class, estimates can be obtained by its use. In the case of velocity-area stations frequent discharge measurements must be made if the estimates are to be other than rough approximations. For stations with beds which shift slowly or are materially changed only during floods, rating tables can be prepared for periods between such changes, and satisfactory results obtained with a limited number of measurements, provided that some of them are taken soon after the change occurs. For streams with continually shifting beds, such as the Colorado and Rio Grande, discharge measurements should be made every two or three days and the discharges for intervening days obtained either by interpolation modified by gage height or by Professor Stout's method, which has been described in full in the Nineteenth Annual Report of the United States Geological Survey, Part IV, page 323, and in the Engineering News of April 21, 1904. This method, or a graphical application of it, is also much used in estimating flow at stations where the bed shifts but slowly.

COOPERATION AND ACKNOWLEDGMENTS.

Most of the measurements presented in this paper have been obtained through local hydrographers. Acknowledgment is extended to other persons and corporations who have assisted local hydrographers or have cooperated in any way, either by furnishing records of the height of water or by assisting in transportation.

The following list, arranged alphabetically by States, gives the names of the hydrographers and others who have assisted in furnishing and preparing the data contained in this report:

California.—The hydrographic work in Susan and Owens rivers drainages in eastern California was under the direction of J. B. Lippincott, supervising engineer; W. B. Clapp, district hydrographer; assisted by R. J. Taylor, J. S. Evans, F. R. S. Buttemer, and J. Branham. The results of the data collected in Owens River Valley are contained in Water-Supply Paper No. 177, which contains the results of all the hydrographic data collected in the State of California during 1905.

The work in the Truckee, Carson, and Walker rivers drainages was under the direction of Henry Thurtell, State engineer of Nevada, assisted by W. A. Wolf.

Idaho.—The work in that portion of Idaho which lies in the Great Basin was under the direction of George L. Swendsen, district engineer, assisted by W. G. Swendsen, hydrographer.

Nevada.—The hydrographic work in this section has been carried on in cooperation with the State by Henry Thurtell, State engineer, assisted by W. A. Wolf. Acknowledgment is due to the Southern Pacific Company and also to the San Pedro, Los Angeles and Salt Lake Railroad Company for transportation furnished.

Oregon.—District engineer, John T. Whistler, assisted by Wilbur C. Sawyer, Edwards N. Smith, and Ivan Landes. Acknowledgment and thanks are due the Oregon Railroad and Navigation Company, the Oregon Short Line Railroad, the Sumpter Valley Railway, and the Columbia Southern Railway Company for transportation furnished.

Utah.—District engineer, George L. Swendsen, assisted by W. G. Swendsen, hydrographer. Acknowledgments are also due to the Oregon Short Line Railroad, the Denver and Rio Grande Railroad, and the San Pedro, Los Angeles and Salt Lake Railroad Company, for transportation furnished; to the Telluride Power Company; Logan River canal companies; Jordan River canal companies, Salt Lake engineer; J. Fewson Smith, jr., water commissioner for Jordan Valley; William Knight, superintendent of pumping plant at Utah Lake; and others who have given assistance from time to time. All daily papers of the State have supported the work strongly and have done much to emphasize the importance of hydrographic information to a proper development of irrigation interests.

GENERAL DESCRIPTION OF THE GREAT BASIN.

In the interior of the North American continent, west of the Rocky Mountains, is an immense area known as the Great Basin, the streams of which do not discharge to the ocean. The area is not one single drainage basin, but consists rather of a number of basins, some of which are connected and others closed; the outer rim of all, however, is at such an elevation that the region as a whole has no surface outlet.

In outline the Great Basin is rudely triangular. It is bordered on the west by the Sierra Nevada, on the north by the Columbia plateaus, on the east by the Rocky Mountains and the Colorado plateaus, and the southern extremity extends almost to the Gulf of California. This inclosed area is approximately 800 miles long from north to south, 500 miles broad at its widest part, and has been estimated to include 208,000 square miles. It comprises the western part of Utah, almost all of Nevada, and contiguous parts of Idaho, Oregon, and California.

Topographically this interior drainage area is characterized by isolated, narrow mountain ranges, trending north and south, which are seperated by broad valleys varying considerably in altitude. In the southern part the valleys are low, Death Valley being below sea level, while in the north the valleys have a general elevation of from 4,000 to 5,000 feet. The intervening highlands often rise several thousand feet above their bases, and some of the peaks of the bordering ranges attain elevations of 13,000 feet above sea level.

Upper branches of the intermontane valleys extend into the interior ranges as narrow drainage ways that are dry during most of the year; but the drainage from the high mountains on the east and west borders of the basin passes through deep canyons into the broad valleys, where the perennial streams maintain lakes. Among these are Great Salt, Utah, and Sevier lakes in the eastern part, and Pyramid, Winnemucca, Honey, Walker, Mono, and Owens lakes in the western part of the Great Basin. With the exception of Utah Lake, which discharges by Jordan River into Great Salt Lake, these lakes are saline in character, as a consequence of the concentration of salts due to evaporation. Bear Lake, in the mountains of the eastern border, and Lake Tahoe, in the Sierras, are large bodies of fresh water that drain, respectively, to Great Salt and Pyramid lakes. Shallow, temporary bodies of water accumulate in some of the broad intermontane valleys during the wet season, but completely evaporate during the summer, leaving muddy plains called playas.

Geologically the Great Basin is well known as the type region of the "Basin Range structure." Many of the isolated, narrow mountain ranges that trend north and south are steep on one side, exposing cross sections of the rocks, and sloping on the other, conforming with the dip of the strata. These ranges have been uplifted by movements of the earth's crust which have broken it into tilted blocks. The greatest displacements of the Great Basin are associated with the eastern and western borders, the Wasatch Mountains and the Sierra Nevada having been uplifted many thousand feet. The mountains of the Great Basin are commonly composed of Paleozoic strata, often modified by vulcanism, and the products of weathering and disintegration of these rocks have accumulated in the broad intervening valleys, which are strewn to great depths with unconsolidated débris.

The climate of the Great Basin is extremely arid, and except a few favored spots where irrigation is practiced, the region in general is a desert. Over the larger part of the area the annual precipitation is less than 10 inches, but it is greater on the bordering high lands, especially on the Sierra Nevada, where it is over 40 inches. Temperature varies widely, owing to the large extent of the area and to differences in elevation. Over most of the region the heat of the summer days is intense, but the diurnal variation is considerable. Evaporation is enormous. From the surface of water in the vicinity of Salt Lake City it amounts to about 60 inches in a year, and over the major part of the Great Basin it is much greater, amounting in places possibly to 150 inches.

An arid climate, however, has not always prevailed in this region. In late geologic time (early Quaternary) the bordering high mountains supported glaciers, and enormous lakes, the old shore lines of which are now plainly marked on the sides of many valleys, accumulated in the Great Basin. The two largest of these lakes have been named after early explorers. Lake Bonneville occupied a considerable part of western Utah, its shrunken remnants being represented by Sevier, Utah, and Great Salt lakes; and Lake Lahontan covered an immense area in western Nevada.

The chief rivers of the Great Basin rise in the mountains which form its eastern and western borders and receive their principal supply from melting snow. The nature of the stream discharge is characteristic; the maximum commonly occurs in late spring or early summer, after which the flow decreases, reaching a minimum during the winter months. After leaving the mountains the streams receive little or no increment; in the broad, waste-filled valleys evaporation and seepage cause diminution in size, and often they entirely cease to flow.

For convenience of treatment, the drainage of the Great Basin has been divided into four areas, viz, Wasatch Mountains, Humboldt Sink, Sierra Nevada, and minor Great Basin drainages. The data collected in these areas during 1905 are given in the following pages:

WASATCH MOUNTAINS DRAINAGE.

PRINCIPAL STREAMS.

The Wasatch Mountains drainage area includes the western half of Utah and small portions of Idaho and Wyoming. The headwaters of the various streams lie either in the Wasatch Mountains or in the plateaus to the south, and they drain either into Great Salt Lake or Sevier Lake. The following are the principal rivers of the area:

Bear and Weber rivers, discharging into Great Salt Lake.

City, Parleys, Emigration, Mill, and Big and Little Cottonwood creeks, tributary to Jordan River and thus to Great Salt Lake. These creeks have small watersheds, but in the mountain courses maintain perennial flows. On reaching the main valley they are extensively used for irrigation and the first three furnish the chief water supply for Salt Lake City.

American Fork and Hobble creeks, Spanish Fork, and Provo River, discharging into Utah Lake.

Sevier River, with its tributary, San Pitch River, draining into Sevier Lake.

BEAR RIVER BASIN.

DESCRIPTION OF BASIN.

Bear River rises on the northern slope of the Uinta Mountains, in the northeastern part of Utah, and after a circuitous course—in which it leaves Utah and enters Wyoming, reenters Utah, appears again in Wyoming, and makes a long detour in Idaho—it returns again to Utah and finally discharges its waters into Great Salt Lake. The maximum elevation of the upper rim of the basin is 13,000 feet.

In the upper part of its course, above the Dingle gaging station, the country is rough and broken, the rocks of the extreme headwater regions being principally sandstone and quartzite, covered with a thin layer of soil which supports scattered groves of fir and aspen. Farther down the prevailing formation is a compact limestone covered with a clayey soil, generally dry and with a rank growth of sagebrush. The tributary streams are numerous and well distributed, but they are generally short and confined to steep, narrow canyons. There are no marshes, extensive meadows, or forests, but a few small lakes lie near the head of the river. Numerous small springs and the melting snow which comprises the greater part of the precipitation are the chief sources of suppply. The annual high-water period occurs during May and June, and the stream is not subject to quick floods or freshets.

Just below Dingle the main stream passes through the north end of Bear Lake Valley in a well-defined channel with no overflow, and from this point to Preston it is confined largely to a steep, narrow canyon, with occasional small, narrow valleys containing irrigated farms. The tributaries in this portion of the basin are few, the principal ones being Mink and Cottonwood creeks. About 10 miles below Dingle the outlet to Bear Lake joins the river. This is a small, crooked, sluggish stream, that discharges but little water at any time, though it is the only visible outlet to Bear Lake, which has an area of about 144 square miles.

The total unappropriated flow between Dingle and Preston is used for irrigation. There is no storage on the main stream, but on Mink Creek a number of small storage reservoirs are contemplated or in process of construction, the water to be diverted for the irrigation of lands in the northwest end of Cache Valley.

Between Preston and Collinston the Bear is a sluggish stream, traversing the west side of Cache Valley in a well-defined channel, which during extreme floods overflows slightly and covers a very narrow strip immediately along the river. The principal tributary streams in this portion of the course are Cub Creek and Logan River. The former has its source in the Bear River Range, and drains a rough country composed of limestone with but little overlying soil. The creek is confined to a steep, narrow canyon until it reaches Cache Valley, where it flows sluggishly for about 15 miles through a winding, but well-defined, channel into Bear River. It discharges considerable water into the main stream during flood and winter seasons, but its entire summer flow is used for irrigation in the north end of Cache Valley. A gaging station was maintained during a part of 1900 and 1901 on Cub Creek about 4 miles northeast of Franklin, at the mouth of the canyon, but, owing to unfavorable conditions, it was discontinued.

Logan River enters the Bear about 7 miles above the gaging station at Collinston, a short distance above the point where it leaves Cache Valley and enters the canyon.

Practically the only inflow to the Bear in Cache Valley is from seepage and springs. The lower portions of the valley form an artesian basin containing numerous small, flowing wells. The water table lies very near the surface, and during the early spring the lower lands are largely swamp.

The Bear River Canal Company diverts the entire summer flow of the stream above Collinston onto agricultural lands lying on both sides of the river below Bear River Canyon. This system has a capacity of about 1,000 second-feet, and during the winter and flood seasons a part of the water is used to develop electric power at a point about one-fourth mile above the Collinston station, being returned to the river at Collinston. From 10 to 30 second-feet reach the stream through leaks and as seepage from the diversion canals.

Owing to the complete control of the stream by irrigation works, the discharge is liable to extreme variation at any period.

BEAR LAKE AT FISHHAVEN, IDAHO.

This station was established October 5, 1903. It is located at Fishhaven, Idaho, on the west shore of Bear Lake, about 4 miles north of the Idaho-Utah State line. It is on land used as a summer resort, owned by G. C. Gray, of Montpelier, Idaho, and is immediately south of the summer resort known as Nelsons Camp.

A plain staff gage, read when the surface of the lake is calm by John L. Nelson, is driven vertically into the bed of the lake 10 feet east of a crib where water from a spring rises to the surface. The gage is protected by 2 by 4 inch stakes driven on either side. The spring melts the ice before the regular breaking-up season, the consequence being that the shore at this point is comparatively free from ice, while only a few hundred feet away it is piled up in great, grinding masses. The gage is referred to bench marks as follows: (1) A wooden hub driven flush with the ground, 1 foot south of a 15-inch cottonwood tree, 1 foot east of a fence on the east side of the county road, 142 feet north of the gage, and about 18° to the west; elevation above zero of gage, 12.19 feet. (2) A shoulder cut on an above-ground root of a 20-inch cottonwood tree, 2 feet southeast of the southeast corner of the porch of a house on the summer-resort grounds; it bears 81° W., 93 feet south of the gage rod; elevation above zero of gage, 7.13 feet. By readings on the lake surface here and at the north end of the lake, October 5, 1903, the elevation of the zero of gage was found to be 12.26 feet by the datum used on canal surveys, etc., during 1903. This elevation is probably correct to within 0.05 foot. The elevation above sea level is approximately 6,000 feet.

An extreme high-water mark pointed out by the observer, who has lived here thirty-three years, indicates that twenty or thirty years ago the surface of the lake stood at approximately gage height 6.5 feet. A more definite mark shows a gage height of 6 feet as occurring twenty years ago

Daily gage height, in feet, of Bear Lake at Fishhaven, Idaho, for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
2									2.7			
5	2.5							3.0				
6		2.55										
8				2.9			3.05			2.4		
10			2.7			3.15						1.85
11											2.05	
12								2.9				
14					3.15				2.6			
15		2.55										
16	2.5									2.3		
17			2.7	2.95								
18												1.8
19								2.8				
20						3.15	3.03				2.0	
22		2.6										
23					3.2							
24	2.5											
25			2.75	2.1								
26									2.5	2.2		
27												1.8
28		2.65										
29							3.03					
30				3.05		3.1						
31	2.5		2.8		3.25						1.9	

NOTE.—Lake frozen over from February 22 to March 17.

BEAR RIVER AT DINGLE, IDAHO.

This station was established May 9, 1903. It is located in a cut made by the Oregon Short Line Railroad Company one-fourth mile east of the Dingle railroad station and about 250 feet south of the track.

The channel is straight for about 400 feet above and below the station. Both banks are high, are not liable to overflow, and are barren except for small brush. The bed of the stream is of well-compacted small gravel and soil and seems to be permanent. The velocity is moderate at ordinary stages, and is well distributed. The stream freezes over late in November or early in December, and ordinarily the ice does not begin to break up until late in February. There is no anchor or needle ice at any stage. Winter records at this station are of special importance, as the object of the station is the collection of facts concerning the amount of water available for storage in Bear Lake.

Discharge measurements are made by means of a cable and car of the regular form, the length of the span being 151 feet. The cable is marked at 10-foot intervals with white paint. The initial point for soundings is the first mark from the north and is 8 feet from the north cable support.

The gage, which is read daily by M. K. Hopkins, was originally of the vertical type, but in December, 1905, it was replaced by a new inclined gage, consisting of a 6 by 6 inch fir, fastened to three vertical double posts well embedded in the bank. It is located 3 feet below the old gage and about 25 feet above the cable. The datum of the new gage was made to agree with that of the old one. The gage is referred to bench marks as follows: (1) A United States Geological Survey standard metallic post bearing N. 33° 15′ E., 37 feet from as north end of cable; elevation above zero of gage, 15.59 feet; elevation above mean sea level, determined from Oregon Short Line Railroad elevations, 6,000 feet. (2) Top of south cable post; elevation, 18.04 feet above zero of gage. (3) Top of 4-foot stick of timber planted 2.7 feet in the ground; elevation above zero of gage, 18.42 feet. During the winter of 1904–5 gage readings were taken once or twice each week, the surface of the water being read after the ice had been cut around the gage and the thickness of the ice in each case noted.

Information in regard to this station is contained in the following Water-Supply Papers of the United States Geological Survey:

Description: 100, p 135; 133, p 238.
Discharge: 100, p 135; 138, p 238.
Discharge, monthly: 100, p 137; 133, p 240.
Gage heights: 100, p 136; 133, p 239.
Rating table: 100, p 136; 133, p 240.

Discharge measurements of Bear River at Dingle, Idaho, in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
February 13 [a]	C. Tanner	92	136	1.43	[b] 4.45	194
March 24	W. G. Swendsen	107	210	1.80	4.22	379
September 19	do	97	136	.98	3.48	133

[a] Stream frozen; ice 1 foot thick near the center and increasing gradually to 1.5 feet at either side. No anchor or slush ice.
[b] Surface of water in hole cut in ice.

Daily gage height, in feet, of Bear River at Dingle, Idaho, for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.8	......	......	4.2	4.2	3.7	3.85	3.35	3.3	3.5	3.55	3.5
2	4.7	......	4.8	4.1	4.15	3.95	3.8	3.4	3.3	3.5	3.55	3.5
3	4.6	4.8	......	4.1	4.2	4.0	3.75	3.35	3.3	3.5	3.55	3.5
4	4.6	4.8	4.7	4.1	4.2	3.95	3.75	3.4	3.3	3.5	3.6	3.55
5	4.4	4.8	......	4.1	4.2	4.05	3.8	3.4	3.3	3.5	3.55	3.5
6	4.4	......	4.45	4.05	4.15	4.2	3.8	3.35	3.4	3.5	3.55	3.5
7	4.5	......	4.45	4.0	4.1	4.25	3.65	3.3	3.4	3.5	3.55	4.4
8	4.5	......	......	4.0	4.1	4.5	3.5	3.3	3.4	3.5	3.5	4.4
9	4.5	......	4.4	4.1	4.1	4.65	3.4	3.3	3.4	3.5	3.55	4.5
10	4.5	......	......	4.1	4.1	4.6	3.45	3.3	3.4	3.5	3.55	4.25
11	4.6	4.6	4.4	4.1	4.05	4.6	3.5	3.3	3.4	3.5	3.55	......
12	4.6	......	4.4	4.1	4.05	4.7	3.5	3.3	3.35	......	3.55	......
13	......	4.45	4.7	4.1	4.0	4.9	3.65	3.3	3.35	3.5	3.5	......
14	4.6	4.45	4.4	4.1	4.0	5.0	3.7	3.3	3.35	3.5	3.55	4.35
15	......	......	4.4	4.15	4.0	4.8	3.7	3.3	3.35	3.5	3.55	......
16	......	......	4.45	4.2	3.9	4.7	3.7	3.3	3.35	3.5	3.55	......
17	4.7	......	4.45	4.2	3.9	4.75	3.65	3.3	3.35	3.5	3.5	4.6
18	......	4.45	4.4	4.2	4.0	4.9	3.6	3.3	3.35	3.5	......	......
19	......	......	4.4	4.2	3.9	5.05	3.6	3.3	3.45	3.5	3.55	......
20	......	......	4.4	4.2	3.9	4.95	3.6	3.2	3.5	3.5	3.55	......
21	4.7	......	4.4	4.2	3.9	4.8	3.6	3.2	3.5	3.5	3.5	4.9
22	......	4.7	4.3	4.2	3.9	4.65	3.55	3.2	3.5	3.5	3.55	......
23	......	......	4.3	......	3.95	4.35	3.5	3.2	3.5	3.5	3.55	......
24	4.8	......	4.2	4.2	3.95	4.2	3.5	3.2	3.5	3.5	3.55	......
25	......	4.7	......	4.2	3.95	4.1	3.5	3.2	3.5	3.55	3.55	3.8
26	......	......	4.2	4.2	3.9	4.0	3.4	3.2	3.45	3.55	3.55	......
27	......	4.8	4.2	4.2	3.9	3.95	3.4	3.2	3.5	3.55	......	......
28	4.7	......	4.2	4.2	3.8	4.0	3.35	3.3	3.45	3.55	3.5	3.8
29	......	......	4.2	4.2	3.8	3.95	3.3	3.3	3.5	3.6	3.3	......
30	4.8	......	4.2	4.1	3.8	3.9	3.4	3.3	3.5	3.55	3.2	......
31	......	......	4.2	......	3.75	......	3.35	3.3	......	3.55	......	4.0

NOTE.—River frozen January 1 to about March 14 and December 7 to 31. During this period the readings were to the water surface in a hole cut in the ice.

The following thicknesses of ice were recorded:

	Thickness in feet.
January 4	0.75
January 8	1.0
January 21	1.2
January 24	1.2
January 28	1.2
February 4	1.1
February 5	1.1
February 11	1.1
February 18	1.2
February 22	1.2
February 25	1.3
February 27	1.3
March 2	1.2
March 6	.7

March 11, ice nearly gone. March 18, no ice at gage.

Station rating table for Bear River at Dingle, Idaho, from March 11 to December 6, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.10	60	3.90	260	4.70	590	5.50	1,020
3.20	75	4.00	295	4.80	635	5.60	1,085
3.30	90	4.10	330	4.90	685	5.70	1,155
3.40	110	4.20	370	5.00	740	5.80	1,230
3.50	135	4.30	410	5.10	790	5.90	1,300
3.60	160	4.40	455	5.20	840	6.00	1,375
3.70	190	4.50	495	5.30	895	6.10	1,460
3.80	225	4.60	540	5.40	955		

The above table is applicable only for open-channel conditions. It is based on 11 discharge measurements made during 1903-1905. It is well defined between gage heights 3.5 feet and 7.4 feet. Above gage height 6.1 feet the rating curve is a tangent, the difference being 90 per tenth.
The above table is the same as that used for 1904.

Estimated monthly discharge of Bear River at Dingle, Idaho, for 1905.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
January	310	180	259	15,920
February	310	195	259	14,380
March	590	180	365	22,440
April	370	295	348	20,710
May	370	208	294	18,080
June	765	190	467	27,790
July	242	90	157	9,654
August	110	75	89	5,472
September	135	90	113	6,724
October	100	135	138	8,485
November	160	75	141	8,390
December 1-6	147	135	137	1,630
The period				159,700

NOTE.—Discharge interpolated for days when the gage was not read.
Estimates for January, February, and March corrected for effect of ice. They are merely approximate.

BEAR RIVER NEAR PRESTON, IDAHO.

This station was established October 11, 1889. It is located about 6 miles from Preston, Idaho, 10 miles north of the Idaho-Utah boundary line and about 300 feet below the county road crossing at the old bridge of the Oregon Short Line Railroad. The data collected at this station are of extreme importance as showing the amount of water that passes from Idaho into Utah and will be of great value in the final adjudication of water rights on the stream.

The channel is straight for about 250 feet above and below the station. Both banks are barren and are sufficiently high to prevent overflow. The bed of the stream is of gravel and clay and is permanent. A light growth of moss near the north side of the gaging section interferes slightly with summer records; otherwise the conditions are good. The stream is ice covered from about the end of December to the middle of February. There is no needle ice and but little fluctuation.

Discharge measurements are made by means of a cable and car, rebuilt in 1904. The cable has a span of about 250 feet and is marked at 10-foot intervals with red paint. The initial point for soundings is the north post supporting the cable.

The gage, which is read daily by Mrs. Hannah Nelson, was originally of the vertical type and consisted of a board nailed to a pile of the highway bridge. This was replaced August 4, 1899, by a wire gage, which proved unsatisfactory, and October 31, 1903, a new temporary gage was again attached to the bridge pile. In December, 1904, a new inclined gage was established at a point about 50 feet below the bridge. It consists of a piece of 8 by 8 inch fir, supported by three vertical double posts. The bench mark is a United States Geological Survey standard metallic post, set flush with the surface of the ground at a point about 8 feet upstream from the south post supporting the cable; elevation above zero of gage, 7.428 feet. All readings have been reduced as nearly as possible to the same datum.

Information in regard to this station is contained in the following publications of the United States Geological Survey (Ann=Annual Report; Bull=Bulletin; WS=Water-Supply Paper):

Description: Ann 14, ii, pp 118-119; 18, iv, p 313; Bull 131, p 53; 140, pp 225; WS 16, p 157; 28, p 146; 38, pp 332-333; 51, p 409; 66, p 117; 85, p 82; 100, pp 133-134; 133, p 241.

Discharge: Ann 18, iv, p 314; Bull 131, pp 53, 92; 140, p 226; WS 16, p 157; 28, p 153; 35, pp 18-19; 38, p 333; 51, p 409; 66, p 117; 85, p 83; 100, p 134; 133, p 241.

Discharge, monthly: Ann 11, ii, p 102; 12, ii, pp 352, 360; 13, iii, p 96; 14, i, p 119; 18, iv, p 315; 19, iv, p 432; 20, iv, p 450; 21, iv, p 394; 22, iv, p 407; Bull 140, p 227; WS 75, p 191; 85, p 84; 133, p 243.

Discharge, yearly: Ann 11, ii, p 99; 13, p 99; 20, iv, p 60.

Gage heights: Bull 131, pp 54-55; 140, p 226; WS 11, p 76; 16, p 157; 28, p 149; 38, p 334; 51, p 410; 66, p 117; 85, p 83; 100, p 134; 133, p 242.

Hydrographs: Ann 12, ii, p 330; 14, ii, p 118; 18, iv, p 316; 19, iv, p 433; 20, iv, p 400; 22, iv, p 407; 75 p 191.

Rating tables: Ann 18, iv, p 314; 19, iv, p 432; Bull 131, p 54; 140, p 226; WS 28, p 154; 39, p 452; 52, p 521; 66, p 176; 85, p 84; 133, p 242.

Discharge measurements of Bear River near Preston, Idaho, in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
January 25	W. G. Swendsen	188	348	1.78	1.60	617
February 17[a]	C. Tanner	197	524	1.46	2.80	766
March 23	W. G. Swendsen	192	470	2.26	2.15	1,059
March 23	do	192	470	2.27	2.15	1,067
May 3	do	196	513	2.64	2.45	1,354
June 7	do	187	358	1.60	1.45	574
July 11	do	152	203	.89	.60	182
August 23	W. D. Beers	145	216	.82	.60	177
September 16	W. G. Swendsen	171	239	1.22	.80	291
October 30	do	186	340	1.56	1.43	528

[a] Back water caused by a large quantity of floating ice piled up near the gaging station. This rendered the velocity zero for 60 feet in the middle of the stream. There was a small amount of ice on the edges of the stream at the gaging station, but none near the gage.

Daily gage height, in feet, of Bear River near Preston, Idaho, for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.6	1.5	1.5	1.88	2.15	1.7	....	0.5	0.7	1.0	1.04	1.3
2	2.6	1.5	1.52	1.8	2.33	1.7	....	.5	.7	1.0	1.04	1.25
3	2.6	1.6	1.55	1.8	2.42	1.62	....	.5	.7	1.07	1.04	1.25
4	2.6	1.6	1.6	1.8	2.38	1.6	....	.5	.7	1.18	1.04	1.25
5	2.5	....	1.6	1.8	2.3	1.63	0.6	.62	.7	1.32	1.04	1.25
6	2.5	1.6	1.68	1.8	2.23	1.53	.62	.5	.7	1.3	1.04	1.2
7	2.45	1.6	1.68	1.8	2.1	1.43	.7	.5	.72	1.3	1.04	1.37
8	2.4	1.6	1.72	1.8	2.1	1.47	.68	.5	.7	1.3	1.04	1.3
9	2.4	1.6	1.78	1.8	2.1	1.4	.63	.5	.7	1.3	1.04	1.4
10	2.4	1.8	1.78	1.8	2.1	1.43	.6	.5	.7	1.3	1.04	1.4
11	2.4	1.9	1.85	1.8	2.05	1.53	.6	.5	.7	1.3	1.04	1.5
12	2.4	....	1.92	1.8	2.05	1.65	.6	.5	.72	1.3	1.04	1.7
13	2.4	....	2.0	1.8	2.0	1.67	.6	.5	.8	1.35	1.04	2.0
14	2.4	....	2.07	1.87	1.95	1.85	.6	.5	.8	1.32	1.04	2.6
15	....	2.8	2.15	1.9	1.95	1.68	.6	.5	.8	1.22	1.04	......
16	3.5	2.72	2.2	1.9	2.0	1.6	.6	.5	.8	1.05	1.04	......
17	3.5	2.7	2.15	1.97	2.05	1.72	.6	.5	.8	1.05	1.35	......
18	3.5	2.55	2.25	2.02	2.15	1.87	.6	.5	.77	1.04	1.3	2.65
19	1.5	2.57	2.3	2.08	2.15	1.9	.6	.5	.7	1.04	1.3	......
20	1.5	2.48	2.27	2.0	2.15	1.9	.6	.5	.8	1.04	1.35	......
21	1.5	1.5	2.23	1.95	2.1	1.65	.8	.5	.8	1.04	1.32	......
22	1.5	1.5	2.2	1.97	2.07	1.5	.8	.6	.8	1.04	1.3	......
23	1.6	1.5	2.12	2.0	2.0	1.42	.8	.75	.8	1.04	1.3	2.45
24	1.6	1.5	2.1	2.0	1.95	1.32	.8	.63	.8	1.04	1.27	......
25	....	1.58	2.05	2.07	1.9	1.25	.75	.7	1.0	1.04	1.25	......
26	1.55	1.6	2.07	2.1	1.9	1.2	.7	.67	.95	1.45	1.25	......
27	1.5	1.55	2.1	2.05	1.9	1.0	.65	.65	.9	1.45	1.25	......
28	1.5	1.52	2.0	2.05	1.9	....	.6	.7	1.0	1.45	1.25	......
29	1.5	....	2.0	2.05	1.87	....	.6	.7	1.0	1.45	1.27	......
30	1.5	....	2.0	2.05	1.8	....	.55	.7	1.0	1.41	1.3	......
31	1.5	....	1.95	....	1.72	....	.52	.7	....	1.41	....	......

NOTE.—River frozen January 1-18 and February 10-20. Ice conditions December 7-31.

Station rating table for Bear River near Preston, Idaho, from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.50	158	1.10	371	1.60	642	2.10	1,020
.60	186	1.20	418	1.70	708	2.20	1,110
.70	217	1.30	468	1.80	779	2.30	1,205
.80	251	1.40	522	1.90	855	2.40	1,300
.90	288	1.50	580	2.00	935	2.50	1,400
1.00	328						

NOTE.—The above table is applicable only for open-channel conditions. It is based on 15 discharge measurements made during 1904-5. It is well defined throughout.

Estimated mon

Month.
January 19-31...........
February 1-9; 21-28......
March....................
April....................
May......................
June.....................
July.....................
August...................
September................
October..................
November.................
December 1-6.............
The period........

NOTE.-

BE

This station was est on the Oregon Short in Bear River Canyon Salt Lake valleys, at unappropriated water

The stream at this overflow; the west b of bowlders and clay material which was w during 1903 changed section was rechecked original standard cro ranges from 2 to 4 fe bank. The discharg summer, when the probably never freez December and Janua

Discharge measure chain and pulley to ments were made fr owing to poor condit January, 1905. Th intervals with paint,

The gage, which is consisted originally by a horizontal bar an inclined gage. firmly embedded in point as the old ve the stream about 50

Estimated monthly discharge of Bear River near Preston, Idaho, for 1905.

[Drainage area, 4,500 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January 19-31	642	580	595	15,340	0.132	0.064
February 1-9; 21-28	642	580	615	20,740	.137	.087
March	1,205	580	907	55,770	.202	.233
April	1,020	779	871	51,830	.194	.216
May	1,320	722	991	60,930	.220	.254
June	855	328	599	35,640	.133	.148
July	251	164	201	12,360	.045	.052
August	234	158	176	10,820	.039	.045
September	328	217	250	14,880	.056	.062
October	551	328	420	26,380	.095	.110
November	495	346	401	23,860	.089	.099
December 1-6	468	418	443	5,272	.098	.022
The period				333,800		

NOTE.—Discharge interpolated on days when gage was not read.

BEAR RIVER NEAR COLLINSTON, UTAH.

This station was established July 1, 1889. It is located 6 miles from Collinston station on the Oregon Short Line Railroad, about one-fourth mile below the electric-power plant in Bear River Canyon. It is at the lower end of the canyon separating Cache and Great Salt Lake valleys, at a point below all diversion from the stream. It shows the amount of unappropriated water that is discharged as waste into Great Salt Lake.

The stream at this point is wide and shallow. Both banks are sufficiently high to prevent overflow; the west bank slopes gradually, while the east is abrupt. The bed is composed of bowlders and clay and is somewhat rough, but apparently permanent. A deposit of material which was washed into the stream by the water from a spillway at the power plant during 1903 changed the original condition considerably during 1903 and 1904. The cross section was rechecked, however, in March, 1905, and found to agree very closely with the original standard cross section, the new material having been washed out. The velocity ranges from 2 to 4 feet per second. There is a free flow except at a small hole near the east bank. The discharge ranges from 7,000 feet during flood season to nothing during the summer, when the entire flow is diverted for irrigation above the station. The stream probably never freezes entirely over, but ice forms along the edges to quite an extent during December and January.

Discharge measurements were originally made from a small boat attached by means of a chain and pulley to a cable stretched across the stream. During 1904 discharge measurements were made from a bridge recently built across the stream at the power house, but owing to poor conditions at this point a cable and car were established at the old section in January, 1905. The total length of the span is 301 feet. The cable is marked at 20-foot intervals with paint, beginning at the west post, which is the initial point for soundings.

The gage, which is read daily by D. A. Cannon, a watchman along the Bear River canals, consisted originally of a vertical iron bar driven into the river bed and supported at the top by a horizontal bar fastened to posts on the bank. It was replaced in February, 1905, by an inclined gage. This is a 6 by 6 inch fir, fastened by means of iron straps to three posts firmly embedded in the bank, and graduated to read vertically. It is located at the same point as the old vertical gage. The low-water gage is an iron peg driven into the bed of the stream about 50 feet from the west bank. It has the same datum as the regular gage.

The gage is referred to bench marks as follows: (1) A metallic post, 3 inches in diameter and 4 feet long, set in the ground at a point 30 feet S. 74° W. from the west post supporting the cable; elevation, 9.59 feet above zero of gage, and so stamped on the top; (2) a nail in an oak post 20 feet west of the gage and 20 feet north of the cable; elevation above gage datum, 7.35 feet.

Information in regard to this station is contained in the following publications of the United States Geological Survey (Ann=Annual Report; Bull=Bulletin; WS=Water Supply Paper):

Description: Ann 18, iv, p 319; Bull 131, pp 55-56; 140, p 227; WS 16, p 159; 28, p 146; 38, pp 335-336; 51, p 413; 66, p 120, 85, p 80; 100, p 131; 133, p 433.

Discharge: Ann 18, iv, p 319; Bull 131, pp 90, 92; 140, p 228; WS 16, p 159; 28, p 153; 35, pp 18-19; 38, p 336; 51, p 413; 66, p 120; 85, p 80; 100, p 131; 133, p 244.

Discharge, monthly: Ann 11, ii, p 103; 12, ii, pp 352, 360; 13, iii, p 96; 14, ii, pp 120-121; 18, iv, p 320; 19, iv, p 435; 20, iv, pp 458-460; 21, iv, p 305; 22, iv, p 410; Bull 140, p 229; WS 75, p 103; 85, p 82; 100, p 133; 133, p 245.

Discharge, yearly: Ann 11, ii, p 60; 13, iii, p 99; 20, iv, p 60.

Gage heights: Bull 131, pp 56-57; 140, p 229; WS 11, p 77; 16, p 159; 28, p 150; 38, p 336; 51, p 414; 66, p 121; 85, p 81; 100, p 132; 133, p 244.

Hydrographs: Ann 12, ii, p 332; 14, ii, p 121; 18, iv, p 320; 19, iv, p 435; 20, iv, p 461; 21, iv, p 305; 22 iv, p 411.

Rainfall and run-off relation: Ann 20, iv, p 459.

Rating tables: Ann 18, iv, p 320; 19, iv, p 434; Bull 140, p 228; WS 28, p 154; 39, p 453; 52, p 521; 66, p 176; 85, p 81; 100, p 132; 133, p 245.

Discharge measurements of Bear River near Collinston, Utah, in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet*	*Second-feet.*
February 10	C. Tanner	270	486	2.46	1.75	1,195
March 20	W. G. Swendsen	275	711	2.73	2.50	1,943
March 29	do	275	711	2.78	2.50	1,976
May 17	do	275	684	2.79	2.45	1,910
September 7[a]	A. B. Larson	19	19	1.64	.37	31
October 31	W. G. Swendsen	268	406	2.32	1.60	1,039

[a] 350 feet below regular station.

diameter
ıpporting
(2) a nail
ion above

ıns of the
S=Water

pp 335-336;

18-19; 38, p

8, Iv, p 320;
p 82; 100, p

ı, p 414; 66,

v, p 395; 22

. p 521; 66, p

.	Dis-charge.
	Second-feet.
5	1,195
0	1,943
0	1,976
5	1,910
7	31
0	1,039

Daily gage height, in feet, of Bear River near Collinston, Utah, for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.7	1.9	1.95	2.35	2.6	2.25	−0.1	−0.5	−0.5	1.2	1.55	1.4
2	1.8	1.95	1.95	2.3	2.8	2.2	− .1	− .5	− .5	1.2	1.55	1.45
3	1.75	2.0	2.0	2.2	3.1	2.1	− .15	− .5	− .5	1.1	1.55	1.45
4	1.75	2.0	2.0	2.15	3.15	2.1	....	− .55	− .5	1.1	1.55	1.45
5	1.8	2.0	2.0	2.1	3.0	2.05	− .2	− .55	− .5	1.1	1.55	1.5
6	1.9	2.0	1.95	2.1	2.9	1.95	− .2	− .55	− .5	1.1	1.55	1.45
7	1.8	1.9	1.9	2.1	2.75	1.8	− .25	− .55	....	1.1	1.6	1.4
8	1.6	1.85	1.95	2.15	2.65	1.6	− .25	− .55	− .4	1.15	1.6	1.3
9	1.75	1.8	1.95	2.2	2.6	1.4	− .3	− .55	− .4	1.15	1.6	1.2
10	1.9	1.75	1.9	2.2	2.6	1.35	− .3	− .55	− .4	1.2	1.6	1.1
11	1.7	1.7	1.9	2.3	2.6	1.3	− .4	− .55	− .4	1.2	1.6	1.0
12	1.7	1.5	1.95	2.3	2.6	1.3	− .4	− .55	− .35	1.2	1.6	1.0
13	1.8	1.3	2.0	2.25	2.6	1.35	− .45	− .5	− .3	1.2	1.6	1.05
14	1.6	1.4	2.1	2.2	2.5	1.4	− .45	− .5	− .3	1.25	1.55	1.05
15	1.6	1.6	2.1	2.3	2.4	1.4	− .45	− .5	+ .3	1.3	1.55	1.1
16	1.65	1.7	2.1	2.3	2.4	1.35	− .5	− .5	.3	1.3	1.55	1.1
17	1.7	1.7	2.1	2.3	2.4	1.3	− .5	− .5	.3	1.3	1.55	1.15
18	1.75	1.7	2.15	2.3	2.5	1.4	− .5	− .55	.3	1.35	1.55	1.15
19	1.75	1.7	2.25	2.4	2.8	1.4	− .5	− .55	.4	1.4	1.5	1.2
20	1.75	1.65	2.5	2.6	2.95	1.45	− .5	− .55	.4	1.45	1.5	1.25
21	1.7	1.65	2.4	2.6	3.0	1.45	− .5	− .55	.4	1.45	1.5	1.25
22	1.75	1.7	2.35	2.55	3.0	1.4	− .5	− .55	.4	1.4	1.45	1.2
23	1.8	1.7	2.35	2.55	2.9	1.35	− .45	− .55	.4	1.45	1.45	1.2
24	1.8	1.8	2.4	2.5	2.85	1.1	− .45	− .5	.35	1.5	1.45	1.25
25	1.85	1.9	2.4	2.45	2.8	.6	− .45	− .5	.3	1.5	1.45	......
26	1.85	1.9	2.4	2.5	....	.6	− .45	− .45	.3	1.5	1.45	1.3
27	1.85	1.9	2.5	2.55	....	.55	− .45	− .45	.35	1.5	1.45	1.35
28	1.85	1.95	2.5	2.6	2.5	.55	− .5	− .5	.7	1.5	1.45	1.4
29	1.9	....	2.5	2.6	2.55	.55	− .5	− .5	.65	1.5	1.5	1.45
30	1.95	....	2.4	2.6	2.55	.5	− .5	− .5	.7	1.5	1.5	1.4
31	2.0	....	2.4	....	2.4	....	− .5	− .5	....	1.6	....	1.35

Station rating table for Bear River near Collinston, Utah, from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second feet.*	*Feet.*	*Second feet.*	*Feet.*	*Second feet.*	*Feet.*	*Second feet.*
−0.55	10	0.40	266	1.40	868	2.40	1,850
−0.50	15	.50	310	1.50	950	2.50	1,960
−0.40	29	.60	356	1.60	1,035	2.60	2,075
−0.30	47	.70	406	1.70	1,125	2.70	2,190
−0.20	68	.80	460	1.80	1,220	2.80	2,310
−0.10	92	.90	518	1.90	1,320	2.90	2,435
.00	120	1.00	580	2.00	1,420	3.00	2,560
.10	152	1.10	646	2.10	1,525	3.10	2,690
.20	187	1.20	716	2.20	1,630	3.20	2,830
.30	225	1.30	790	2.30	1,740		

NOTE.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904-05. It is well defined between gage heights 1.3 feet and 2.5 feet.

Estimated monthly discharge of Bear River near Collinston, Utah, for 1905.

[Drainage area, 6,000 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January	1,420	1,035	1,199	73,720	0.200	0.231
February	1,420	790	1,199	66,590	.200	.208
March	1,960	1,320	1,605	98,690	.268	.309
April	2,075	1,525	1,800	107,100	.300	.335
May	2,760	1,850	2,201	135,300	.367	.423
June	1,685	310	895	53,260	.149	.166
July	120	15	36.4	2,238	.0061	.0070
August	22	10	13.0	779	.0022	.0025
September	406	15	158	9,402	.026	.029
October	1,035	646	806	49,560	.134	.154
November	1,035	909	976	58,080	.163	.182
December	950	580	767	47,160	.128	.148
The year	2,760	10	971	701,900	.160	2.17

NOTE.—Discharge interpolated on days when gage was not read. Discharge applied for open channel during winter months.

LOGAN RIVER NEAR LOGAN, UTAH.

Logan River rises on the west slope of the Bear River Range, flows southwest, then northwest, and unites with Bear River near Benson, Utah. The entire basin is rough and rugged, the elevations ranging from 4,500 to 9,000 feet and the stream being confined largely to a steep and rough channel in a comparatively narrow canyon. The principal formation is a compact limestone, with little or no soil except near the summit of the range, where a thin layer supports quite extensive groves of fir and aspen. The lower reaches of the stream are practically barren of timber, except for a few scattered pine and mahogany trees and a rather thick growth of underbrush. A large amount of timber has been cut out and the area has been overgrazed by sheep and cattle. There are no flood basins or marshes in the region. Probably three-fourths of the precipitation in the basin is snow, the melting of which forms the chief source of supply for the spring and early summer flow; the late summer and winter flow is derived chiefly from springs, which are well distributed over the basin. In its upper course the stream has numerous small tributaries, all short and swift. Temple Fork and South Fork, which enter the river about 10 and 15 miles, respectively, above the gaging station, are perennial streams and furnish from one-third to one-fourth of the total flow. Blacksmith Fork comes in below the gaging station. There is no storage on the stream at present. The entire flow, after being utilized to furnish power at two electric plants near the mouth of the canyon, is used for irrigation.

A gaging station was established June 1, 1896, about 2 miles east of the city of Logan, near the mouth of the canyon. It was discontinued July 18, 1903, and reestablished April 13, 1904, at a point along the canyon road about 50 feet below the highway bridge, at the mouth of the canyon, 800 feet below the Hercules power house and about 1,000 feet above the old gaging station.

Th channel is straight for about 150 feet above and 75 feet below the gaging section. The banks are of rock and soil, permanent, and ... sufficiently high to prevent overflow. The bed of the stream was originally of bowlders and gravel, well cemented together, very rough, and of such shape that the stream was not well distributed. When the station was reestablished the channel was improved by removing large bowlders and sufficient of the finer material to distribute the flow and render the bed comparatively smooth. During the spring flood of 1904 a deposit of bowlders and gravel was made at the section, reducing it to about the original conditions, but leaving a loose and probably shifting bed. There is but one channel at all stages. Discharge ranges from about 150 to 1,000 second-feet, with a velocity of from 3 to 7 feet per second. The depth is 1.5 to 3.5 feet. There are no dams or riffles and the grade of the stream is about uniform. Winter flow is affected but little by ice, as the stream never freezes over.

Discharge measurements are made by means of a cable and car of the regular form. The cable is marked at 4-foot intervals with red paint. A guy line is stretched about 25 feet above the cable, for use during high water. The initial point for soundings is a 4 by 4 inch post, set in the west bank and projecting about 4 feet above the ground.

Observations are taken by the Telluride Power Company, under the direction of E. P. Bacon, manager. The gage is of the vertical type, consisting of a 2 by 2½ inch steel rod, with the upstream side drawn to an edge. It is driven into the bed of the stream and is supported at the top by a horizontal 4 by 4 inch fir buried in the bank and fastened to a vertical post near the water edge. The bench mark is a United States Geological Survey standard metallic plug, cemented in a limestone ledge 250 feet N. about 30° W. of the cable, on a prominent point near the north side of a road leading to the power house; elevation, 24.85 feet above zero of gage; elevation above mean sea level, as determined from Oregon Short Line Railroad elevations, 4,502 feet.

Information in regard to this station is contained in the following publications of the United States Geological Survey (Ann=Annual Report; WS=Water-Supply Paper):

Description: Ann 18, iv, pp 316–317; 19, iv, p 433; 20, iv, p 462; 21, iv, p 397; WS 16, p 158; 28, p 146; 38, p 334; 51, p 411; 66, p 118; 85, pp 86–87; 100, p 137; 133, p 246.
Discharge: Ann 18, iv, p 317; WS 16, p 158; 28, p 153; 38, p 335; 51, p 411; 66, p 118; 85, p 87; 100, p 137; 133, p 246.
Discharge, monthly: Ann 18, iv, p 318; 19, iv, p 434; 20, iv, p 462; 21, iv, p 397; 22, iv, p 408; WS 75, p 192; 133, p 248.
Discharge, yearly: Ann 20, iv, p 60.
Gage heights: WS 11, p 77; 16, p 158; 28, p 150; 38, p 335; 51, p 412; 66, p 119; 100, p 138; 133, pp 247, 248.
Hydrographs: Ann 19, iv, p 434; 20, iv, p 463; 22, iv, p 409.
Rating tables: Ann 18, iv, p 318; 19, iv, p 433; WS 28, p 154; 39, p 453; 52, p 521; 66, p 176; 133, p 247.

Discharge measurements of Logan River near Logan, Utah, in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
January 22	W. G. Swendsen	51	49	3.16	4.40	155
February 21	do	50	49	3.26	4.45	160
March 21	do	51	52	2.57	4.40	134
April 17	do	51	58	3.02	4.50	175
June 5	do	57	109	5.86	5.61	637
August 21	W. D. Beers	52	56	2.79	4.55	155
August 24[a]	do	39	59	2.53	4.48	149
September 14	W. G. Swendsen	51	50	3.20	4.52	161
October 29	do	51	43	2.89	4.40	124
November 26	do	51	42	3.02	4.37	126

[a] Measured 300 feet below station.

Daily gage height, in feet, of Logan River near Logan, Utah, for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.45	4.48	4.4	4.43	4.9	5.5	5.1	4.50	4.5	4.43	4.4	4.33
2	4.4	4.48	4.38	4.41	4.95	5.5	5.05	4.6	4.5	4.43	4.4	4.31
3	4.4	4.53	4.38	4.41	4.9	5.55	5.05	4.57	4.5	4.43	4.4	4.32
4	4.4	....	4.4	4.41	4.85	5.55	5.05	4.57	4.5	4.4	4.4	4.31
5	4.4	4.5	4.4	4.41	4.75	5.57	5.0	4.57	4.52	4.4	4.4	4.25
6	4.4	4.4	4.4	4.4	4.7	5.58	4.95	4.57	4.52	4.4	4.4	4.25
7	4.4	4.4	4.4	4.45	4.75	5.45	4.9	4.57	4.53	4.4	4.4	4.25
8	4.4	4.4	4.4	4.45	4.8	5.5	4.85	4.57	4.5	4.42	4.4	4.25
9	4.4	4.4	4.42	4.48	4.85	5.5	4.8	4.57	4.48	4.45	4.4	4.25
10	4.4	4.4	4.42	4.46	4.75	5.5	4.75	4.56	4.48	4.45	4.4	4.27
11	4.4	4.4	4.42	4.5	4.8	5.5	4.7	4.56	4.48	4.45	4.4	4.33
12	4.35	4.25	....	4.47	4.8	5.5	4.7	4.56	4.48	4.43	4.4	4.33
13	4.35	4.28	4.42	4.46	4.8	5.45	4.67	4.56	4.47	4.43	4.4	4.36
14	4.45	4.3	4.42	4.5	4.85	5.45	4.65	4.56	4.47	4.43	4.38	4.32
15	4.43	4.35	4.42	4.45	4.75	5.4	4.65	4.55	4.47	4.43	4.38	4.35
16	4.44	4.38	4.48	4.49	4.85	5.4	4.65	4.55	4.5	4.43	4.38	4.38
17	4.43	4.35	4.48	4.47	4.93	5.35	4.65	4.54	4.45	4.43	4.38	4.3
18	4.43	4.3	4.47	4.48	5.3	5.2	4.65	4.54	4.45	4.45	4.35	4.35
19	4.43	4.35	4.45	4.5	5.3	5.2	4.65	4.55	4.47	4.45	4.35	4.38
20	4.43	4.3	4.47	4.5	5.3	5.1	4.65	4.54	4.47	4.45	4.35	4.35
21	4.43	4.3	4.41	4.55	5.3	5.1	4.65	4.5	4.46	4.43	4.35	4.38
22	4.45	....	4.45	4.55	5.25	5.07	4.65	4.54	4.45	4.43	4.33	4.38
23	4.45	4.38	4.4	4.65	5.25	5.1	4.65	4.5	4.45	4.42	4.35	4.33
24	4.47	4.4	4.45	4.65	5.2	5.1	4.65	4.48	4.45	4.42	4.35	4.35
25	4.45	4.38	4.43	4.65	5.25	5.1	4.6	4.5	4.48	4.42	4.35	4.35
26	4.45	4.3	....	4.7	5.3	5.1	4.6	4.5	4.49	4.4	4.32	4.4
27	4.43	4.38	4.42	4.8	5.3	5.1	4.6	4.48	4.47	4.4	4.29	4.38
28	4.43	4.38	4.45	4.8	5.35	5.1	4.6	1.5	4.47	4.4	4.4	4.38
29	4.43	....	4.45	4.75	5.3	5.1	4.6	4.5	4.47	4.4	4.38	4.38
30	4.43	....	4.45	4.8	5.3	5.1	4.6	4.45	4.45	4.4	4.3	4.35
31	4.43	....	4.45	....	5.35	....	4.6	4.5	....	4.4	....	4.38

NOTE.—Stream does not freeze at this point during winter months in sufficient amount to materially affect the rating.

Station rating table for Logan River near Logan, Utah, from April 25, 1904, to December 31, 1905.

Gage height	Discharge	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.30	109	5.00	350	5.70	675	6.40	1,052
4.40	136	5.10	394	5.80	726	6.50	1,108
4.50	164	5.20	438	5.90	779	6.60	1,164
4.60	195	5.30	483	6.00	833	6.70	1,222
4.70	230	5.40	529	6.10	887	6.80	1,280
4.80	268	5.50	577	6.20	941	6.90	1,338
4.90	308	5.60	625	6.30	996		

NOTE.—The above table is applicable only for open-channel conditions. It is based on 21 discharge measurements made during 1904–1905. It is fairly well defined between gage heights 4.4 feet and 6.25 feet.

Estimated monthly discharge of Logan River near Logan, Utah, for 1905.

[Drainage area, 218 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January	155	122	142	8,731	0.651	0.750
February	173	96	131	7,275	.601	.626
March	157	131	144	8,854	.661	.762
April	208	130	177	10,530	.812	.906
May	506	230	368	22,630	1.69	1.95
June	615	382	496	29,510	2.28	2.54
July	394	195	248	15,250	1.14	1.31
August	195	150	176	10,820	.807	.930
September	173	150	158	9,402	.725	.809
October	150	130	143	8,793	.656	.756
November	130	106	120	7,140	.550	.614
December	130	96	118	7,256	.541	.624
The year	615	96	202	146,700	.930	12.62

NOTE.—Discharge interpolated on days when gage was not read.

BLACKSMITH FORK NEAR HYRUM, UTAH.

This stream rises on the western slope of the Bear River Range and flows southwest and then northwest into Logan River. The drainage basin of the tributary is in every way similar to that of the main stream. Only the flood and winter discharge, however, reaches the Logan, the entire spring and summer flow being used for irrigation on the tillable lands below the gaging station.

The gaging station was established July 19, 1900, near the tollgate in the mouth of the canyon near Hyrum, Utah, which is the nearest post-office. The station was discontinued December 31, 1902, and reestablished May 16, 1904, about 1,000 feet downstream from the tollgate and 800 feet above the Hyrum city electric-power plant. A station is also maintained at the power-plant race.

The channel is straight for 200 feet above and 50 feet below the station. The right bank for 20 feet back is a low, wooded flat, subject to overflow during extreme high water; beyond this point the bank is high and barren. The left bank is wooded and high and does not overflow. The bed of the stream is composed of bowlders and gravel and is somewhat rough, but apparently permanent, though a slight change seems to have occurred during December, 1904. During flood stages the velocity is high, ranging from 4 to 6 feet per second; under normal conditions it is 2 to 3 feet per second. The discharge varies from about 80 to 1,000 second-feet. Ice does not form in sufficient quantity to interfere with the results at any stage.

Discharge measurements are made by means of a cable and car of regular form. The cable is marked at 4-foot intervals with red paint. A guy line for use during high water is stretched across the stream about 30 feet above the cable. The initial point for soundings is the south post supporting the cable.

The gage, which is observed daily by Uriah Benson, a farmer living at the tollgate, is of the vertical type, and consists of a 2 by 2½ inch iron bar with the upstream side drawn to an edge, driven into the bed of the stream and supported by a horizontal piece buried in the bank. The gage is referred to bench marks as follows: (1) A United States Geological Survey standard metallic plug, set in a solid limestone ledge about 40 feet east of the north post supporting the cable; elevation above zero of gage, 17.875 feet. (2) Top of the eyebolt of the north anchor of the cable; elevation above zero of gage, 9.578 feet.

Information in regard to this station is contained in the following publications of the United States Geological Survey (Ann = Annual Report; WS = Water-Supply Paper):

Description: WS 51, p 412; 66, p 119; 85, p 84, 133; p 249.
Discharge: WS 51, p 412; 66, p 119; 85, p 85; 133, p 249.
Discharge, monthly: Ann 22, iv, p 409; WS 75, p 192; 85, p 86; 133, p 251.
Gage heights: WS 51, p 413; 66, p 120; 85, p 85; 133, p 250.
Hydrograph: Ann 22, iv, p 410.
Rating tables: WS 52, p 521; 66, p 176; 85, p 86; 133, p 250.

Discharge measurements of Blacksmith Fork near Hyrum, Utah, in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
January 23	W. G. Swendsen	38	35	2.26	3.50	78
February 22	do	38	34	2.32	3.50	80
April 16	do	39	44	2.72	3.70	119
May 4	do	41	58	3.18	3.98	186
July 9	do	39	41	2.29	3.00	95
August 22	W. D. Beers	37	33	1.91	3.60	77
October 28	W. G. Swendsen	30	23	1.23	3.30	28
November 27	do	30	23	1.33	3.31	31

Daily gage height, in feet, of Blacksmith Fork near Hyrum, Utah, for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.5	3.5	3.5	3.6	4.0	4.1	3.6	3.6	4.8	3.6	3.3	3.3
2	3.5	3.5	3.5	3.6	4.0	4.1	3.6	3.6	4.8	3.6	3.3	3.3
3	3.5	3.5	3.5	3.6	4.0	4.1	3.6	3.6	4.8	3.6	3.3	3.3
4	3.5	3.5	3.5	3.6	4.0	4.1	3.6	3.6	4.8	3.6	3.3	3.3
5	3.5	3.5	3.5	3.6	4.0	4.1	3.6	3.6	4.8	3.6	3.3	3.3
6	3.4	3.5	3.5	3.6	3.9	3.9	3.6	3.6	4.8	3.6	3.3	3.3
7	3.4	3.5	3.5	3.6	3.9	3.9	3.6	3.6	4.8	3.6	3.3	3.3
8	3.5	3.5	3.5	3.7	3.9	3.9	3.6	3.6	4.8	3.6	3.3	3.3
9	3.5	3.4	3.5	3.7	3.9	3.9	3.6	3.6	4.8	3.6	3.3	3.3
10	3.5	3.4	3.5	3.6	3.9	3.8	3.6	3.6	4.8	3.6	3.3	3.3
11	3.5	3.4	3.5	3.6	3.9	3.8	3.6	3.6	4.8	3.6	3.3	3.2
12	3.5	3.4	3.5	3.6	3.9	3.8	3.6	3.6	4.8	3.6	3.3	3.2
13	3.5	3.4	3.5	3.7	3.9	3.8	3.6	3.6	4.8	3.6	3.3	3.2
14	3.5	3.5	3.5	3.7	3.9	3.8	3.6	3.6	4.8	3.6	3.3	3.2
15	3.5	3.5	3.5	3.7	3.9	3.8	3.6	3.6	3.6	3.6	3.3	3.2
16	3.5	3.5	3.5	3.7	3.9	3.8	3.6	3.6	3.6	3.6	3.3	3.3
17	3.5	3.5	3.5	3.7	3.9	3.8	3.6	3.6	3.6	3.6	3.3	3.3
18	3.5	3.5	3.5	3.7	4.0	3.8	3.6	3.6	3.6	3.6	3.3	3.3
19	3.5	3.5	3.5	3.8	4.0	3.8	3.6	3.6	3.6	3.6	3.3	3.2
20	3.5	3.5	3.5	3.8	4.0	3.8	3.6	3.6	3.6	3.6	3.3	3.2
21	3.5	3.5	3.5	3.8	4.0	3.8	3.6	3.6	3.6	3.6	3.3	3.2
22	3.5	3.5	3.5	3.8	4.0	3.8	3.6	3.6	3.6	3.5	3.3	3.3
23	3.5	3.4	3.6	3.9	4.1	3.8	3.6	3.6	3.6	3.3	3.3	3.3
24	3.5	3.4	3.6	3.9	4.1	3.8	3.6	3.6	3.6	3.3	3.3	5.3
25	3.5	3.4	3.6	4.0	4.1	3.7	3.6	3.6	3.6	3.3	3.3	3.3
26	3.5	3.5	3.6	4.0	4.1	3.7	3.6	3.6	3.6	3.3	3.3	3.3
27	3.5	3.5	3.6	4.0	4.1	3.7	3.6	3.6	3.6	3.3	3.3	3.3
28	3.5	3.5	3.6	4.0	4.1	3.7	3.6	3.6	3.6	3.3	3.3	3.3
29	3.5	....	3.6	4.0	4.1	3.7	3.6	3.6	3.6	3.3	3.3	3.3
30	3.5	....	3.6	4.0	4.1	3.7	3.6	3.6	3.6	3.3	3.3	3.3
31	3.5	....	3.6	....	4.1	....	3.6	4.8	....	3.3	....	3.3

NOTE.—Stream does not freeze at this point during the winter months in sufficient quantity to materially affect the rating.

Station rating table for

Gage height.	Discharg
Feet	*Second-fe*
3.40	6
3.50	8

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measurements made dur

Station rating table for

Gage height.	Dischar
Feet.	*Second-f*
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3.60	

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Station rating table for Blacksmith Fork near Hyrum, Utah, from January 1 to July 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.40	64	3.60	98	3.80	140	4.00	190
3.50	80	3.70	118	3.90	164	4.10	216

NOTE.—The above table is applicable only for open-channel conditions. It is based on five discharge measurements made during January to July, 1905. It is well defined throughout.

Station rating table for Blacksmith Fork near Hyrum, Utah, from August 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.20	18	3.70	94	4.10	189	4.50	304
3.30	29	3.80	115	4.20	216	4.60	336
3.40	42	3.90	138	4.30	244	4.70	369
3.50	57	4.00	163	4.40	273	4.80	402
3.60	75						

NOTE.—The above table is applicable only for open-channel conditions. It is based on three discharge measurements made during August to December, 1905, and the form of the 1904 curve. It is well defined between gage heights 3.2 feet and 4 feet.

Estimated monthly discharge of Blacksmith Fork near Hyrum, Utah, for 1905.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
January	80	64	79.0	4,858
February	80	64	75.4	4,188
March	98	80	85.2	5,239
April	190	98	132.	7,855
May	216	164	187.	11,500
June	216	118	151.	8,985
July	98	98	98.0	6,026
August	402	75	85.5	5,257
September	402	75	228.	13,570
October	75	29	61.1	3,757
November	29	29	29.0	1,726
December	29	18	26.2	1,611
The year	402	18	103	74,570

NOTE.—Above estimates do not represent total flow of river. See Blacksmith Fork power plant race (pp. 34-35).

BLACKSMITH FORK POWER PLANT RACE, NEAR HYRUM, UTAH.

This station was established May 16, 1904, for the purpose of ascertaining the amount of water diverted around the regular gaging station at the tollgate and thus determining the total flow of the stream at that point. It is located about 600 feet down the canyon road from the tollgate at the mouth of the canyon, about 200 feet below the head of the canal or race, and about 500 feet south of the river station.

The channel is straight for 100 feet above and 200 feet below the station. Both banks are sufficiently high to prevent overflow. The bed of the stream is of gravel and is apparently permanent, except for probable slight changes near the edges. The depth varies from 2 to 3 feet and the velocity from 2 to 3 feet per second. Practically no ice forms in the channel at any time.

Discharge measurements are made from a foot plank placed across the stream and fastened at the ends to pieces of timber buried in the bank. The plank is marked at 1-foot intervals. The initial point for soundings is the north end of the plank, marked zero.

The gage, daily readings of which are made by Uriah Benson, is a 2 by 2¼ inch iron bar driven vertically into the bed of the stream, supported at the top by the plank from which the measurements are made, and graduated by means of punch holes. The bench mark is a point on a projecting rock on the southeast corner of a rock house about 400 feet northwest from the station. It is marked with red paint. Elevation above zero of gage, 8.845 feet.

A description of this station, gage height, and discharge data and rating table are con, tained in Water-Supply Paper No. 133 of the United States Geological Survey, pp. 251-253.

Discharge measurements of Blacksmith Fork power plant race, near Hyrum, Utah, in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
January 23	W. G. Swendsen	12.0	23	2.55	4.50	58
October 28	do	13.5	28	3.02	4.90	83

Daily gage height, in feet, of Blacksmith Fork power plant race near Hyrum, Utah, for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.5	4.5	4.5	4.5	4.5	4.6	4.6	4.6	....	4.4	4.9	4.9
2	4.5	4.5	4.5	4.5	4.5	4.6	4.6	4.6	....	4.4	4.9	4.9
3	4.5	4.5	4.6	4.5	4.5	4.6	4.6	4.6	....	4.4	4.9	4.9
4	4.45	4.5	4.6	4.5	4.5	4.6	4.6	4.6	....	4.4	4.9	4.9
5	4.45	4.5	4.5	4.5	4.5	4.6	4.6	4.6	....	4.4	4.9	4.9
6	4.45	4.5	4.5	4.6	4.5	4.6	4.6	4.6	....	4.4	4.9	4.9
7	4.45	4.5	4.5	4.6	4.4	4.6	4.6	4.6	....	4.4	4.9	4.9
8	4.45	4.5	4.5	4.6	4.4	4.6	4.6	4.6	....	4.4	4.9	4.9
9	4.45	4.4	4.5	4.6	4.4	4.6	4.6	4.6	....	4.4	4.9	4.9
10	4.5	4.4	4.5	4.6	4.4	4.5	4.6	4.6	....	4.4	4.9	4.5
11	4.5	4.4	4.5	4.6	4.4	4.5	4.6	4.6	....	4.4	4.9	4.5
12	4.5	4.4	4.5	4.6	4.4	4.5	4.6	4.6	....	4.4	4.9	4.5
13	4.5	4.4	4.5	4.6	4.4	4.5	4.6	4.6	....	4.4	4.9	4.5
14	4.5	4.5	4.5	4.6	4.4	4.5	4.6	4.6	4.5	4.4	4.9	4.6
15	4.5	4.5	4.5	4.7	4.4	4.5	4.6	4.6	4.5	4.4	4.9	4.7
16	4.5	4.5	4.5	4.7	4.4	4.4	4.6	4.6	4.5	4.4	4.9	4.6
17	4.5	4.45	4.5	4.7	4.4	4.4	4.6	4.6	4.4	4.4	4.9	4.6
18	4.5	4.45	4.5	4.7	4.5	4.4	4.6	4.6	4.4	4.4	4.9	4.5
19	4.5	4.45	4.5	4.8	4.5	4.4	4.6	4.5	4.4	4.4	4.9	4.5
20	4.5	4.45	4.5	4.8	4.5	4.4	4.6	4.5	4.4	4.4	4.9	4.5
21	4.5	4.45	4.5	4.8	4.5	4.4	4.6	4.5	4.4	4.7	4.9	4.6
22	4.5	4.45	4.5	4.8	4.5	4.4	4.6	4.5	4.4	4.9	4.9	4.6
23	4.5	4.45	4.6	4.5	4.5	4.4	4.6	4.4	4.4	4.9	4.9	4.7
24	4.5	4.45	4.6	4.5	4.6	4.4	4.6	4.4	4.4	4.9	4.9	4.7
25	4.5	4.45	4.6	4.5	4.6	4.6	4.6	4.4	4.4	4.9	4.9	4.7
26	4.5	4.45	4.6	4.5	4.6	4.6	4.6	4.3	4.4	4.9	4.9	4.8
27	4.5	4.45	4.6	4.5	4.6	4.6	4.6	4.3	4.4	4.9	4.9	4.8
28	4.5	4.5	4.5	4.5	4.6	4.6	4.6	4.3	4.4	4.9	4.9	4.8
29	4.5	....	4.5	4.5	4.6	4.6	4.6	4.3	4.4	4.9	4.9	4.8
30	4.5	....	4.5	4.5	4.6	4.6	4.6	4.3	4.4	4.9	4.9	4.8
31	4.5	....	4.5	....	4.6	....	4.6	....	....	4.9	....	4.8

NOTE.—Flow not materially affected by ice conditions.